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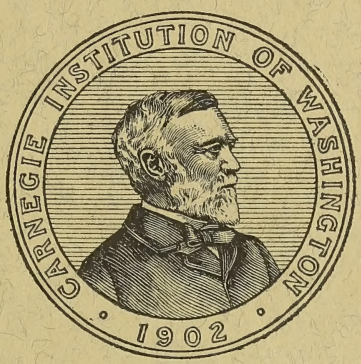
By

Lee R. Dice and Philip M. Blossom

University of Michigan



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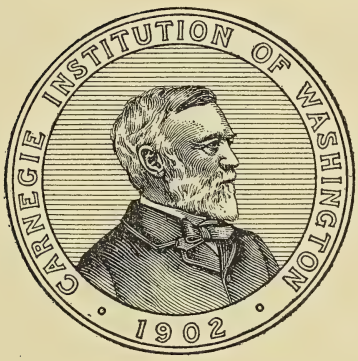

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CONTENTS

ILLUSTRATIONS

PLATES

(See end of text)

TEXT-FIGURES

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INTRODUCTION

Deserts are of particular interest to ecologists on account of the rigor of the desert environment in certain features and the many striking adaptive structures and habits possessed by the plants and animals. In the desert, also, the several types of ecological communities are often sharply distinct from one another, and the line of separation between two adjacent communities often is clearly marked. For these reasons the desert is a particularly good place to study the relationships between organisms and their environments.

The following report covers studies which were begun in 1930, when color differences in the rock pocket mouse (*Perognathus intermedius*) from the various isolated mountains near Tucson, Arizona, were first noted by the senior author. The winter of 1930–1931 was spent by the junior author in the Tucson region, and a general collection was made of the smaller mammals, particular attention being given to the color of the ground and rocks at each trapping station. Obvious color variations were noted in the cactus mouse (*Peromyscus eremicus*) and in the white-throated wood rat (*Neotoma albigula*). On subsequent expeditions both the junior and senior authors gave special attention to the degree of correlation between the colors of the mammals and of the soils of their habitats.

Preliminary reports of these studies have appeared in the Year Books of the Carnegie Institution of Washington, Nos. 30 (p. 266), 31 (pp. 298–299), 32 (pp. 292–293), 33 (p. 268), and 34 (pp. 278–280).

ACKNOWLEDGMENTS

The financial support for the field work in Arizona and Sonora has been provided by the Carnegie Institution of Washington, the Museum of Zoology of the University of Michigan, William P. Harris Jr., and the junior author. It is a pleasure to acknowledge the friendly interest of President John C. Merriam of the Carnegie Institution of Washington, President Alexander G. Ruthven of the University of Michigan, and Director Frederick M. Gaige of the Museum of Zoology of the University of Michigan, whose encouragement and support have made the field work possible. The facilities of the Desert Laboratory of the Carnegie Institution of Washington at Tucson greatly aided the field work, and special thanks are due Director Forrest Shreve for constant helpful advice and assistance. Dr. D. T. MacDougal of the Desert Laboratory gave us much useful advice and for several weeks allowed us the

use of his house on the desert 9 miles north of Tucson. Valuable advice during the field work has been given by Dr. Walter P. Taylor, of the United States Biological Survey, and by Professor Charles T. Vorhies, of the University of Arizona. The officials of the Coronado National Forest, especially Percy Leaverton, provided useful maps and information about the distribution of the larger mammals in the Santa Catalina Mountains. The Arizona Fish and Game Commission supplied the necessary collecting permits.

The identification of the mammals has been greatly aided by the loan of specimens from the California Museum of Vertebrate Zoology and the United States Biological Survey. Considerable aid in the identification of the mammals has been given by Dr. Seth B. Benson and Dr. William H. Burt. Miss Margaret Liebe has assisted in making the tint photometer readings and in the statistical calculations. The maps and graphs were drawn by C. H. MacFadden.

The field work on which this report is based was conducted by both the senior and junior authors, though the two were never in the field at the same time. The junior author has made the tint photometer readings of the skins of the rock pocket mouse, cactus mouse, and white-throated wood rat, and also of the soil samples from the rock hill habitats. He has also made the statistical computations of these readings. Both authors have been involved in the specific identifications of the collections, in the preparation of the annotated list of mammals, and in the descriptions of the collecting localities. The senior author has prepared most of the section dealing with the ecologic communities of southeastern Arizona. The senior author also is mainly responsible for the theoretical discussion, but the junior author, by many suggestions and criticisms, has contributed materially to all sections of the report.

REGIONS STUDIED

The regions considered in this report include southeastern Arizona, southwestern Arizona, and a small part of adjacent Sonora. Also several situations in southern New Mexico, previously described by Dice, by Bradt, and by Benson, are here included as a basis for discussion of the variation of pelage colors in certain rodent species.

The region around Tucson, Arizona, was studied in the spring of 1930 by William P. Harris Jr. and Dice, who arrived at Tucson on March 6. Various collecting stations were established near Tucson, and a more extensive trip was made to Libertad, Sonora, in a caravan led by Forrest Shreve. Harris left the region on March 20, but Dice continued in the field until April 21.

Blossom worked in southern Arizona from December 3, 1930, to April 26, 1931. William Turnage acted as field assistant during March and April. Most of this time was spent around Tucson, and a small collection of mammals was made in Madera Canyon, Santa Rita Mountains, and on the Santa Rita Range Reserve. A brief study was made in the Chíricahua Mountains. Also a brief excursion was made, in company with Forrest Shreve, into southwestern Arizona.

Dice returned to southeastern Arizona in the summer of 1932 and was in the region from June 2 to August 6. Most of this time was spent on the Santa Catalina Mountains, which were studied on their northern slopes down to an elevation of 3750 feet. Two weeks were spent at the eastern base of the Huachuca Mountains.

Blossom made two expeditions to southwestern Arizona in 1932 and 1933. On the first expedition he was in the region from September 24 to October 25, 1932. During a part of this time he accompanied D. T. MacDougal and T. D. Mallery, of the Desert Laboratory, on a trip along the Camino del Diablo. On the second expedition he was accompanied by George D. Clark, of Birmingham, Michigan, and was in the field from April 19 to May 18, 1933. During this time five days were spent in the Pinacate Mountains region of northern Sonora, in company with Gilbert Sykes, Charles Reynard, George Chambers, William E. Bayliss, and Charles Puffer, the last-mentioned acting as guide for the party.

The desert mountains and buttes are composed of many different kinds of rocks, and these rocks are of various colors. They range from very light-colored granite to almost black lava, and others have a distinctly reddish tone. It often happens that rocks of many different colors occur together on the same mountains, but sometimes a mountain or a butte is composed of rocks mostly of one color. If such a mountain is isolated, so that the rock-inhabiting mammals are closely restricted to one color of background, they tend, as shown later in this report, to resemble the color of the rock of their habitat. We shall therefore in our descriptions of collecting localities give special attention to the rock colors.

The altitudes given in this report have been taken from bench marks or topographic sheets of the United States Geological Survey or from an altimeter checked with a bench mark.

SOUTHEASTERN ARIZONA

Southeastern Arizona (fig. 1) is covered by a high, somewhat undulating plateau, from which rise a number of mountain masses. The Chíricahua, Huachuca, Santa Catalina, and Santa Rita Mountains rise to elevations of about 9000 feet or slightly more, but most of the other mountains are small and low. The general plateau is dominated by arid grassland. On the upper parts of the higher mountains grow forests of pines and other conifers. An encinal of oak and juniper forms a lower belt, which also covers the upper parts of the other, lower, mountains. The Sonoran desert which covers southwestern Arizona extends eastward to include the Santa Cruz Valley near Tucson (Shreve, 1913, 1–11).

The desert mountains are usually more or less isolated from one another and most of them rise quite abruptly from the plain. Surrounding each mountain is a broad apron of detritus called a *bahada*, which slopes gently away until it merges with the bahadas of other mountains to form the general "plain" of the desert. The desert "plain," therefore, is not uniform either in slope or in elevation, but rises gradually as mountains are approached and

descends gradually toward the desert basins and toward the major washes. The mountains themselves are usually quite rocky, with many small cliffs and talus slopes. The upper bahadas are usually covered by rocks and stones and are often traversed by rocky washes or arroyos, but the lower desert plain is mostly made up of fine soil, with local underlying beds of hardpan or *caliche*.

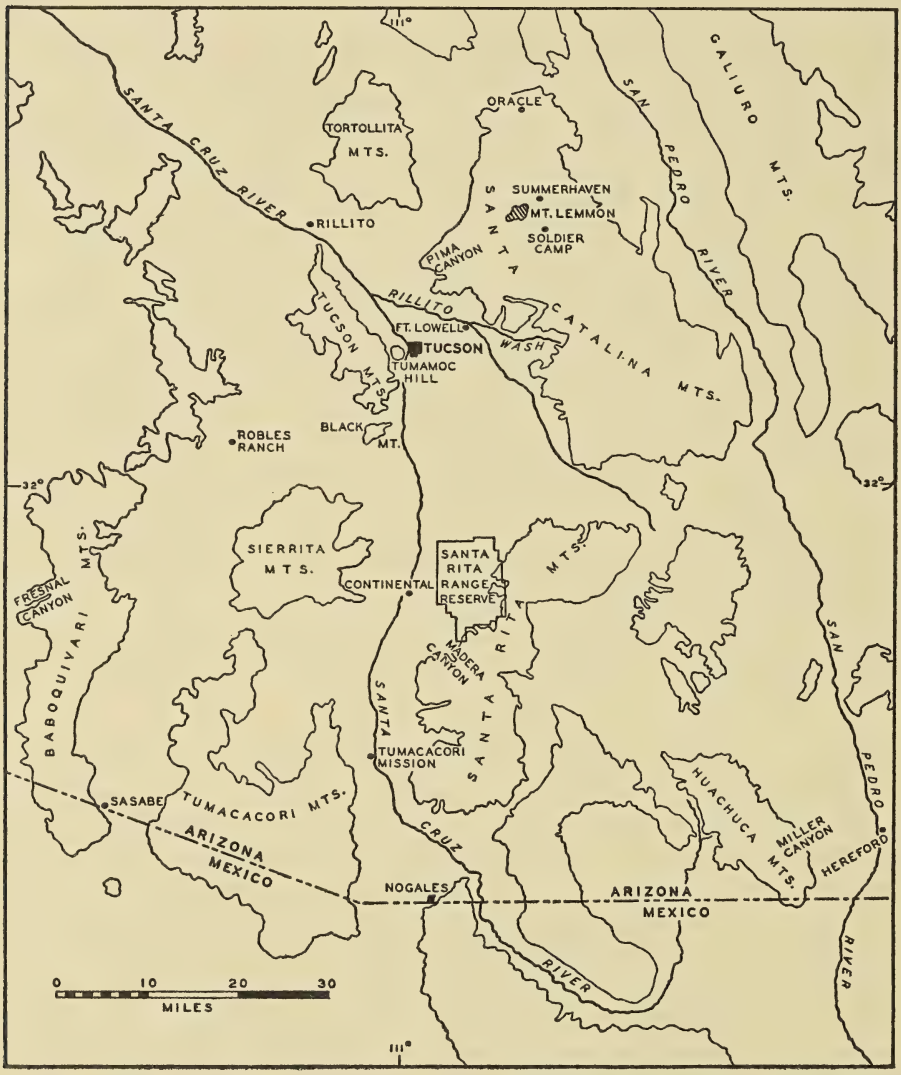

FIG. 1—Map of part of southeastern Arizona, based on maps of the United States Geological Survey.

Detailed descriptions of the ecology of part of southeastern Arizona are given in another section of this report. There follow here brief descriptions of several collecting stations in this region which are of importance in the comparisons made later between soil color and the color of the mammals.

Santa Catalina Mountains. The upper parts of the Santa Catalina Mountains were studied by Dice from June 4 to June 30, 1932. Camp was made in Sabino Canyon about ¾ mile below the little group of summer cottages, hotel, and store known as Summerhaven. The camp was at an elevation of about 7560 feet. Most attention was given to the yellow pine forests on the steep slopes adjacent to the camp and to the streamside association along Sabino Creek. The Douglas fir association and streamside association were studied on the northern slope of Mount Lemmon, which is the highest peak of the mountains and reaches an altitude of 9150 feet.

Oracle and vicinity. Dice worked in the vicinity of Oracle, mostly in Pinal County, Arizona, from June 30 to July 18, 1932. Camp was maintained in Peppersauce Canyon, about 8 miles southeast of Oracle, at an elevation of about 4625 feet. Adjacent to the camp are found the oak, sycamore, and ocotillo associations of the encinal belt. The oak association was also studied at the lower control station on the automobile road at an elevation of about 5590 feet, and near Oracle. The mesquite–grass association of the grassland belt was studied at slightly lower elevations both southeast and northwest within several miles of the camp. An oak wash was studied about 2½ miles north of Oracle and a palo verde–mesquite–grass association about 5 miles north of Oracle.

Pima Canyon. Our collecting station was located on the rocky slopes at the eastern side of the mouth of Pima Canyon. The Santa Catalina Mountains here rise steeply from the upper edge of the bahada, and Pima Canyon opens to the southwestward abruptly from the mountains. The position is about 10 miles north of Tucson and the elevation about 3200 feet. The rocks are a light-colored gneiss of a mottled texture. There is a considerable amount of weather-staining with brown, particularly on the under sides of flat rocks, so that the various rock samples vary considerably in color tone. The vegetation is that typical of south-facing rocky slopes: ocotillo, palo verde, and sahuaro predominate. Dice trapped at this station in 1930 and Blossom in 1931.

At this location Dice trapped also in upper bahada habitat about a mile south of the mouth of Pima Canyon or about 9 miles north of Tucson; in palo verde–*Encelia* association about 8 miles north of Tucson; and in a desert wash, also about 8 miles north of Tucson.

Fort Lowell. Fort Lowell, which is now abandoned, is situated about 7 miles northeast of Tucson, in Pima County, on the south bank of Rillito Wash. Along the wash at this place there is a slight development of the cottonwood–willow association. Blossom studied this association in January 1931.

On the northern side of Rillito Wash at Fort Lowell the banks rise steeply and the plain above is covered with creosote bush. This station is about 8 miles northeast of Tucson and was studied by Blossom in April 1931.

Tortollita Mountains. The Tortollita Mountains are small and low, and none of the peaks rise high enough to carry any type of forest. Our collecting

in these mountains was all conducted at their western border. The locations were nearly north of the railroad station of Rillito and distant from it about 7 to 10 miles. Dice and Harris collected in a small canyon (erroneously supposed by us to be Javelina Canyon) March 8 to 15, 1930. Blossom collected in the larger Javelina (or Coche) Canyon in September 1932.

The rocks of the Tortollita Mountains are like those of the southwestern border of the adjacent Santa Catalina Mountains as represented at the mouth of Pima Canyon, and are therefore quite pale in general color tone. The vegetation is dominated by sahuaro, palo verde, and ocotillo, and is of the same type as that found on all low rocky southerly slopes in this region.

Robles Ranch. To the northwest of Robles Ranch lies an extensive desert plain, with drainage toward the north. The soil is fine and sandy and there are numerous small washes. Toward the lower part of this plain there is a considerable growth of mesquite trees, but many of these have been removed for fence posts and fuel. Around the edges of the plain the characteristic vegetation is the creosote bush. Dice trapped about 5 miles northwest of Robles Ranch, or about 25 miles west of Tucson, April 5 to 8, 1930.

Tucson Mountains. The rock hill community on the lower northeastern slope of the Tucson Mountains in Pima County, about 4 miles west of Tucson, elevation about 2600 feet, was studied by Blossom December 13 to 18, 1930. The color of the rock at this place is strongly reddish brown, a color which occurs extensively throughout the Tucson Mountains. Bryan (1925, 253) states that the cliffy slopes of these mountains have "developed on tilted rhyolitic and andesitic lava flows and plugs. . . . The western front of the mountains consists of Paleozoic limestone and quartzite and Mesozoic shale and quartzite, which are intruded by granite rocks and rhyolite plugs."

Tumamoc Hill. The Desert Laboratory of the Carnegie Institution of Washington is located on Tumamoc Hill at the western edge of Tucson, Pima County, Arizona. This volcanic hill is separated from the Tucson Mountains, which lie to the northwestward, by only a narrow pass. The characteristic vegetation of the rocky slopes of the hill has been described by Spalding (1909, 5–66) and others. The dominant plants are the giant cactus, palo verde, and ocotillo.

The surface rock of most of Tumamoc Hill, including all that part of the hill on which our traps were set, is made up of olivine basalt (Tolman, 1909, 76–77). The basalt was extruded sometime in the Pleistocene. The color of the rock is very dark (plate 4B), though not so black as that of the Tularosa Malpais, and it has a strong tinge of red. The mammals of Tumamoc Hill were studied by Dice in 1930 and by Blossom in 1931 and 1932.

Black Mountain. Black Mountain is the local name applied to an isolated butte of very dark-colored basalt in the Papago Indian Reservation about 10 miles south of Tucson (plate 5A). This butte is about 3 miles in length and about 1 mile across on its base. It rises very steeply from the surrounding sandy desert plain, which has an elevation of about 2600 feet, and its maximum elevation is about 300 feet above the level of the plain. The rocks are

quite uniform in color and are nearly black, but with a reddish tinge, which is most pronounced on the protected lower surfaces of stones lying free on the slopes. A scanty soil of a reddish buff color occurs in some shallow depressions between the rocks. The vegetation is that characteristic of all rocky slopes in the Tucson region. Blossom trapped on Black Mountain in March and April 1931.

Santa Rita Range Reserve. The Santa Rita Range Reserve is under the control of the United States Department of Agriculture. It is an area of nearly 50,000 acres of grazing land at the northwestern base of the Santa Rita Mountains in Pima County, Arizona. It is situated on a northwesterly-sloping bahada between altitudes of 2700 and 4500 feet (Vorhies and Taylor, 1933, 473). The surface soil in most places is fine in texture and its color in general is reddish brown, but varies somewhat from place to place.

The following localities were studied by Blossom in January and February 1931: 25 miles south of Tucson in *Isocoma* association, elevation about 2900 feet; 30 miles south of Tucson in grass–mesquite association, elevation about 3700 feet; 34 miles south of Tucson, near the mouth of Florida Canyon, in grass–mesquite association, elevation about 4000 feet; and 36 miles south of Tucson, mostly beyond the border of the Range Reserve near the mouth of Madera Canyon, in grass–mesquite association, elevation about 4300 feet. Harris and Dice visited the Santa Rita Range Reserve and Madera Canyon on one day in late March 1930, and Dice, accompanied by Charles T. Vorhies, trapped on the Reserve on the night of March 31, 1930.

Madera Canyon. Madera Canyon is located about 40 miles south of Tucson on the northwestern side of the Santa Rita Mountains. Locally it is known as White House Canyon, but we have used the name given by the Patagonia sheet of the United States Topographic Survey. Blossom collected here between elevations of 5200 and 6000 feet, in February 1931, all his collecting stations being in Santa Cruz County. The sycamore association in the bottom of the canyon was studied most intensively, and less attention was given to the oak association on the sides of the canyon.

Miller Canyon. Miller Canyon lies on the eastern side of the Huachuca Mountains, near their southern end, in Cochise County, Arizona. At the mouth of this canyon there is an extensive alluvial fan, which is continuous with the high grassland plain which slopes gently to the San Pedro River. The mouth of the canyon has an elevation of about 5000 feet and is about 9 miles west of the small town of Hereford. The forest of oaks and pines covering the mountains extends over part of the alluvial fan and plain, though the pines have dropped out before the base of the mountain is reached. Along the stream in the canyon occur sycamores, walnuts, and oaks, forming a sycamore association.

Dice worked at the mouth of Miller Canyon from July 20 to August 5, 1932, but a considerable part of this period was very rainy, interfering considerably with the trapping for small mammals.

Hereford. A small town in Cochise County, Arizona, on the San Pedro

River. The elevation at the railroad station is 4135 feet. In early August 1932 Dice trapped in several stations along the river and in several other stations on the grass- and shrub-covered plain between the river and the Huachuca Mountains.

SOUTHWESTERN ARIZONA

Southwestern Arizona is covered by desert, and similar desert conditions prevail over northwestern Sonora and southeastern California. The general contour of the desert plain is broken by numerous low mountain ranges and by many small buttes (fig. 2).

Extremely arid conditions prevail over the lower desert area of the Yuma district. The rainfall is not only small in average annual amount, but very irregular in occurrence. The temperatures of summer are high and the evaporation rates great. On the desert mountains there is little soil and therefore little stored water is available to plants.

Only a few plant species are able to endure the rigorous environment of the rock hill habitat, and vegetation is very sparse in this ecologic community. Several kinds of low shrubs occur, but the most conspicuous plants are the palo verde and the ocotillo. The giant cactus (sahuaro) is rare over most of the Arizona desert, though it is common in places near Tucson and elsewhere. On some of the mountains, especially on the newer lavas, the rocks are very barren and there is almost no vegetation.

Natural rock tanks (*tinajas*) in the mountains supply the only free water which is available to animal life, except during or shortly following a rain. Most of these tanks are small and only a few are large enough to retain water during a prolonged dry period. Many of the mountains entirely lack any permanent supply of water.

Nevertheless a number of species of mammals live in this desert in spite of the lack of water and in defiance of the apparent scantiness of possible food. In some situations small rodents actually occur in considerable numbers. The most common species of mammals living on the rocks are the rock pocket mouse (*Perognathus intermedius*), the cactus mouse (*Peromyscus eremicus*), and the white-throated wood rat (*Neotoma albigula*). The rock pocket mouse and the cactus mouse seem in this region to be closely restricted to the rock habitat, but the wood rat is found also, though less commonly, on the desert plain. The canyon mouse (*Peromyscus crinitus*) and the cactus wood rat (*Neotoma lepida*) are found on a few of the western mountains. Small mammals seem to be most common in the vicinity of a natural water tank, but the plant life is not at all affected by the presence of these reservoirs, for the water does not reach the surrounding soil.

The natural environment of the lower desert region has been little modified by the activities of man. Because of the lack of water no extensive human population could possibly be supported.

Our field work in southwestern Arizona and northern Sonora has been carried out mostly by Blossom, who has made altogether three trips to the

region. He has given especial attention to the rodent faunas of the isolated desert ranges.

Telegraph Pass. Telegraph Pass is in the northern part of the Gila Mountains in Yuma County, Arizona, about 10 miles west of Wellton. Through this pass the highway crosses the Gila Mountains. This is the most westerly

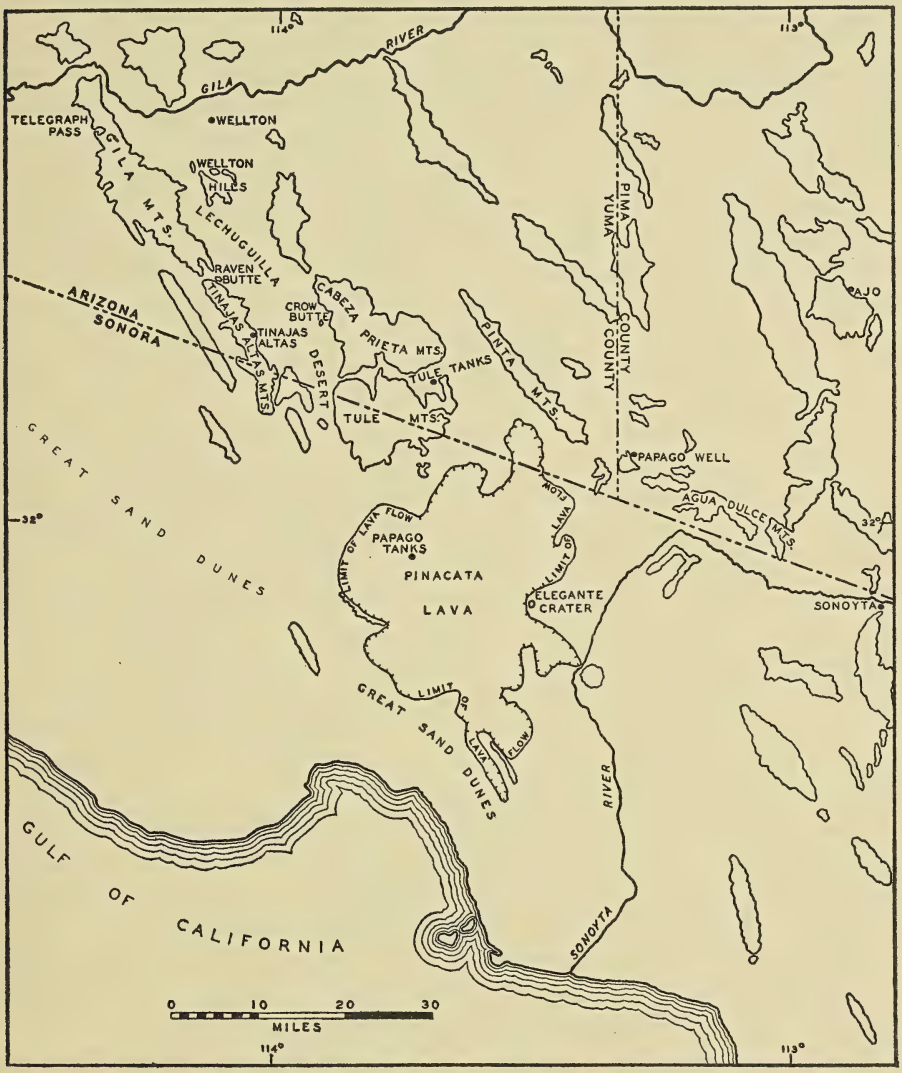

FIG. 2—Map of parts of southwestern Arizona and northwestern Sonora, based on maps of the United States Geological Survey and of Lumholtz.

locality studied by Blossom, who trapped here October 11 to 13, 1932. The rock pocket mouse was common, and 20 were taken in two nights. The total catch was: *Perognathus intermedius intermedius*, rock pocket mouse, 20; *Peromyscus eremicus eremicus*, cactus mouse, 1; *Peromyscus crinitus disparilis*, canyon mouse, 1.

The Gila Mountains are about 25 miles in length and have a northwestern trend. Their breadth varies from 2 to 7 miles. "The northern part of the mountains is composed mostly of schist and gneiss, intruded by pinkish granite; the southern part has large amounts of light-colored granite" (Bryan, 1925, 189). The rock sample collected at Telegraph Pass is quite dark in color.

Wellton Hills. The Wellton Hills are a small isolated group of hills located in Yuma County, Arizona, about 6 miles south of Wellton. Blossom trapped in these hills October 21 to 25, 1932, and found small mammals to be scarce. The following were taken: *Perognathus intermedius intermedius*, rock pocket mouse, 4; *Peromyscus crinitus disparilis*, canyon mouse, 2.

"The hills occupy an area about 6 miles in diameter over which they are scattered singly or in groups." "The hills rise from 50 to 500 feet above the flat-bottomed valleys that pass between them." Some of the hills are carved from lava of Tertiary age. "Other hills are composed of rocks of the crystalline complex, and granite, granite gneiss, and schist were found" (Bryan, 1925, 196–197). At the station where Blossom trapped the rock is rather dark in color.

Tinajas Altas. The tanks of Tinajas Altas are located in the Tinajas Altas Mountains, in Yuma County, Arizona, about 27 miles south of Wellton, and near the Mexican border. Blossom trapped at Tinajas Altas October 18 to 25, 1932, and took the following specimens: *Ammospermophilus harrisii saxicola*, antelope squirrel, 1; *Perognathus baileyi domensis*, Bailey pocket mouse, 1; *Perognathus intermedius phasma*, rock pocket mouse, 17; *Peromyscus eremicus eremicus*, cactus mouse, 16; *Peromyscus crinitus disparilis*, canyon mouse, 2; *Neotoma albigula mearnsi*, white-throated wood rat, 2.

"The Tinajas Altas Mountains are separated from the Gila Mountains by a broad gap and in turn are divided into two parts by a similar gap, through which there is a wagon road. . . . The dominant rocks are light-colored granite and gneiss" (Bryan, 1925, 189).

Raven Butte. Raven Butte lies about 20 miles south of Wellton, in Yuma County, Arizona. It is a small butte about $\frac{1}{4}$ mile east of the northern end of the Tinajas Altas Mountains, with which it is connected by a rocky isthmus. Blossom trapped on Raven Butte October 8 to 20, 1932, and took the following: *Perognathus intermedius phasma*, rock pocket mouse, 11; *Peromyscus eremicus eremicus*, cactus mouse, 19; *Peromyscus crinitus disparilis*, canyon mouse, 5; *Neotoma albigula mearnsi*, white-throated wood rat, 1.

About 200 feet of lava is exposed on Raven Butte (Bryan, 1925, 190). The contrast in rock color between the black lava of Raven Butte and the pale granite of the Tinajas Altas Mountains is very striking (plate 5B). On account of the connecting isthmus of rocks the rock habitat of the butte is not isolated from the rock habitat of the adjacent mountains.

Cabeza Prieta Mountains. Blossom trapped October 15 to 16, 1932, on the western edge of the Cabeza Prieta Mountains, in Yuma County, Arizona, a little over 9 miles east of Tinajas Altas. The rocks at this station are very

light in color though not quite so pale as those of the Tinajas Altas Mountains. Mice were scarce at this station and in two nights Blossom took only: *Perognathus intermedius intermedius*, rock pocket mouse, 4; *Peromyscus crinitus disparilis*, canyon mouse, 1.

"The Cabeza Prieta Mountains are an irregular group of mountains about 10 miles in diameter.... Cabeza Prieta (black head), the high part of the range, is composed of light-colored granular crystalline rock capped by lava. The lava cappings occur also on other mountains of the range" (Bryan, 1925, 190–191).

Crow Butte. The name Crow Butte has been given by Blossom (1933a, 3) to a small butte of very dark-colored lava rock located in Yuma County, Arizona, about 9 miles east of Tinajas Altas (plate 6A, B). Blossom trapped here October 14 to 16, 1932, and found the rock pocket mouse to be common. Other mice were scarce and the total catch was: *Perognathus intermedius intermedius*, rock pocket mouse, 31; *Peromyscus crinitus disparilis*, canyon mouse, 1; *Neotoma lepida auripila*, cactus wood rat, 1.

Crow Butte is close to the Cabeza Prieta Mountains, which lie to the east. Only about $\frac{1}{4}$ mile of sand plain separates the butte from the mountains.

Tule Tank. Tule Tank is in the Tule Mountains in Yuma County, Arizona, about 17 miles southeast of Tinajas Altas. Blossom trapped on rocky ledges near the water hole one night on each of two occasions, October 15, 1932, and May 5, 1933. The bahada pocket mouse was taken on a gravelly slope, while the other specimens here listed were trapped on rocky slopes: *Ammospermophilus harrisii saxicola*, Harris antelope squirrel, 2; *Perognathus amplus rotundus*, bahada pocket mouse, 1; *Perognathus intermedius intermedius*, rock pocket mouse, 7; *Peromyscus eremicus eremicus*, cactus mouse, 3; *Peromyscus crinitus disparilis*, canyon mouse, 1.

The Tule Mountains lie on the Mexican boundary, immediately to the southeast of the Cabeza Prieta Mountains, from which they are imperfectly separated. They "consist of more or less detached ridges and sierras, which are large and bold in Mexico but become lower on the broad pass which separates this range from the Cabeza Prieta Mountains. The Tule Mountains are composed mostly of granite and gneiss, but on the western border is a monoclinal ridge of lava in which at least 500 feet of beds are exposed" (Bryan, 1925, 191). In color the rocks of these mountains closely resemble those of the Cabeza Prieta Mountains.

Pinacate lava plain in Arizona. A small lava butte on the northern extension of the Pinacate lava sheet in Yuma County, Arizona, about 20 miles east of Tule Tank, was trapped by Blossom for one night only, May 8, 1933. The location is about 3 miles north of the Mexican boundary. Here were taken the following: *Perognathus intermedius pinacate*, rock pocket mouse, 28; *Peromyscus eremicus pinacate*, cactus mouse, 3; *Neotoma albigula mearnsi*, white-throated wood rat, 1.

Agua Dulce Mountains. Blossom collected in the Agua Dulce Mountains, 9 miles east of Papago Well, in Pima County, Arizona, just north of the

Mexican border, on October 3, 1932, and on May 7 and 18, 1933. He found the rock pocket mouse numerous, but other mammals were scarce. His collecting station is the type locality of *Neotoma lepida auripila*. The following were taken: *Perognathus intermedius intermedius*, rock pocket mouse, 26; *Peromyscus eremicus eremicus*, cactus mouse, 3; *Neotoma albigula mearnsi*, white-throated wood rat, 1; *Neotoma lepida auripila*, cactus wood rat, 5.

The pocket mice, cactus mice, and cactus wood rat were taken on rocks near the summit of the mountains, but the white-throated wood rat was taken in creosote bush association near the base of the mountains.

The Agua Dulce Mountains lie on the Mexican Boundary, and are completely isolated from other mountains by wide plains of desert sand. They "consist of three parts of about equal length which are divided by narrow passes." The indication is "that these mountains are composed wholly of the coarse-grained granitic rocks of the crystalline complex" (Bryan, 1925, 194). The sample secured by Blossom at the trapping location is composed of coarse crystalline rock predominantly dark red in color tone.

Fresnal Canyon. This station is located in Fresnal Canyon close to the Allison Reservoir at the northwestern base of the Baboquivari Mountains. It is in Pima County, Arizona, about 20 miles southeast of Indian Oasis (Sells), and has an elevation of about 2800 feet. Near the Allison Reservoir the lower slopes of the range are for the most part composed of undisintegrated rock, which in nearly all places is exposed at the surface. Because of the almost total lack of soil the vegetation is very scanty. The color of the extensive rock formations here is distinctly reddish in tone.

Blossom collected at this station March 19, 1931. On the rocks he took 3 rock pocket mice (*Perognathus intermedius intermedius*) and 1 cactus mouse (*Peromyscus eremicus eremicus*). On the adjacent upper bahada he secured 2 wash pocket mice (*Perognathus penicillatus pricei*) and 1 round-tailed spermophile (*Citellus tereticaudus neglectus*). He also shot 2 canyon bats (*Pipistrellus hesperus* subspecies). The small number of specimens taken indicates a scanty population of small mammals, which is correlated with the barrenness of the environment.

"The Baboquivari Mountains are composed of rocks of the crystalline complex. . . . The north end of the range, composed of granite and granitic gneiss, is high, precipitous, and rough" (Bryan, 1925, 247).

NORTHWESTERN SONORA

Northwestern Sonora is covered by desert plains from which rise isolated mountain ranges, and is very similar in topography, flora, and fauna to southwestern Arizona (fig. 2). Around the head of the Gulf of California is an extensive area of moving sand, which we did not study. Just south of the Arizona border an extensive area is covered by the nearly black Pinacate lava, and a small part of this lava flow extends across the border into Arizona.

The Pinacate Mountains consist of a number of low volcanic cones. The main mass of lava surrounding these mountains extends unbroken approximately 18 miles in north and south dimension and about 12 miles in east and west dimension. Numerous other volcanic craters and lava flows of the same type of nearly black basaltic lava occur in the surrounding area, and it is estimated (Lumholtz, 1912, 211) that within an area 45 miles long and 30 miles wide no other type of rock exposure is to be found, except in a few small spots, as at Papago Tanks, where the overlying lava has been completely eroded away. Altogether several hundred volcanic cones and craters occur in the Pinacate area. Some of these cones are completely isolated by varying distances of desert sand plain, but the lava of all is of much the same type.

The prevailing southwesterly winds carry much loose light-colored sand from the Gulf of California and have heaped it up on the sides of the more western craters. Some craters have been almost completely buried by these drifting sands.

On the upper slopes of craters lying toward the northeastern side of the Pinacate area the ground is covered by volcanic ashes and cinders and larger lava blocks. The size of these materials gradually decreases toward the bottoms of the crater slopes, until on the surrounding desert the volcanic material consists of very fine black dust. This dust gives the ground a nearly black surface, and perhaps the tendency to dark pelage color noted in some specimens of *Perognathus penicillatus* from this region is related to the dark color of the surface soil.

The color of the freshly exposed Pinacate lava is nearly black, and is only slightly tinged with red. The texture is dull and not shining. On the western side of the Pinacate area the color of the lava is much more reddish and less strikingly black than in the rest of the area.

Papago Tanks. Three natural rock tanks (plate 8B) on the western edge of the Pinacate lava flow hold the only permanent nonalkaline water between this locality and the village of Sonoyta, Sonora, which lies 60 miles to the eastward.

Blossom found small mammals numerous here and in two nights' trapping, April 25 and 26, 1933, he collected the following species and individuals: *Perognathus amplus rotundus,* bahada pocket mouse, 1; *Perognathus penicillatus pricei,* wash pocket mouse, 7; *Perognathus intermedius pinacate,* rock pocket mouse, 24; *Dipodomys merriami simiolus,* Merriam kangaroo rat, 5; *Peromyscus eremicus papagensis,* cactus mouse, 15; *Neotoma albigula sheldoni,* white-throated wood rat, 4; *Neotoma lepida bensoni,* cactus wood rat, 2.

On the black lava rocks (plate 8A) he took all the wood rats of both species listed above, all the cactus mice, and 12 of the rock pocket mice. On the nearly black gravelly slopes of the adjacent plain he secured the kangaroo rats, the bahada pocket mouse, the wash pocket mice, and 12 of the rock pocket mice.

The occurrence of rock pocket mice on this gravelly plain is perhaps to be explained by the occurrence here of a few large volcanic boulders. It is very

unusual to find *Perognathus intermedius* and *Perognathus penicillatus* living in the same habitat, as they did at this locality.

The animal population in the vicinity of these tanks is abundant, and there is much evidence of the continued use of the tanks by both the large and the small desert animals. The scanty vegetation on the rocks above the tanks is dominated by ocotillo and palo verde, while the gravelly slopes below the tanks support nearly a pure stand of creosote bush. Several collections of mammals have been made at these tanks by previous explorers, and Papago Tanks is the type locality of several races of dark-colored mammals.

Elegante Crater. Elegante Crater is located near the eastern edge of the Pinacate lava, in Sonora, about 40 miles west of Sonoyta. The lava flow from Elegante Crater is separated from the main Pinacate lava mass by about ¼ mile of desert sand. The lava forming the slopes of the crater is of a very dark color, very similar to that of the other Pinacate lavas. On the lower slopes of the crater the pale-colored sand of the desert plain is thinly covered by a very fine black volcanic dust, so that the soil surface appears nearly black (plate 7B).

Blossom trapped on this crater for one night only, April 24, 1933. The mammals taken were: *Perognathus baileyi baileyi*, Bailey pocket mouse, 1; *Perognathus penicillatus pricei*, wash pocket mouse, 1; *Perognathus intermedius pinacate*, rock pocket mouse, 14; *Dipodomys merriami simiolus*, Merriam kangaroo rat, 1.

On the rocky upper slopes of the crater he secured 5 rock pocket mice and noted the presence of wood rats. On gravelly cinder slopes farther down the crater *Encelia farinosa* is the dominant plant, but the creosote bush is common. A few large volcanic boulders occur. Here were secured 1 Bailey pocket mouse, 1 Merriam kangaroo rat, and 6 rock pocket mice. No signs of wood rats could be found. On sandy lower slopes the creosote bush is the dominant plant, and here were taken 1 wash pocket mouse and 3 rock pocket mice. The occurrence of the rock pocket mouse in this lower station is unusual, because no rocks are present in this habitat; however, there are many sand washes, and perhaps the rock pocket mouse follows these washes down across the plain, as it is known to do in other parts of the desert.

Pinacate lava near Elegante Crater. Only about ¼ mile from the edge of the lava thrown out by Elegante Crater rises the eastern border of the main Pinacate lava bed. This Pinacate lava sheet rises abruptly from the desert sand to a height of 25 or 30 feet, and extends back to the slopes of the Pinacate Mountains about 4 miles to the westward. The lava sheet here is much broken, making trapping difficult. Blossom trapped here one night only, April 24, 1933, but small mammals proved to be scarce and only the following were taken: *Perognathus penicillatus pricei*, wash pocket mouse, 1; *Perognathus intermedius pinacate*, rock pocket mouse, 4; *Neotoma albigula sheldoni*, white-throated wood rat, 1; *Neotoma lepida bensoni*, cactus wood rat, 1.

The presence of the one wash pocket mouse in this predominantly rocky habitat is perhaps to be explained by the occurrence among the volcanic rocks of small tongues of sand, which extend into the lava flow from the desert plain. Our records fail to indicate whether or not this one *Perognathus penicillatus* was taken on such a sand tongue, but it probably was.

Sasabe to Libertad. The vegetation and physiography of the region between the Mexican boundary, at Sasabe, and the Gulf of California, at Libertad, has already been described by Shreve (1924, 283–293). Dice and Harris accompanied a party, led by Forrest Shreve, which made a round trip over this route March 22 to 29, 1930.

SOUTHERN NEW MEXICO

The New Mexican areas to be discussed in this report include the Tularosa Malpais, the Tularosa White Sands, and the Kenzin lavas (fig. 3).

Tularosa White Sands. An area of about 270 square miles in Otero County, New Mexico, is covered by drifting gypsum sands (Benson, 1933, 9–12). These gypsum sands are nearly white in color, but have a faint tinge of buff. They are nearly 95 per cent gypsum. A very pale-colored pocket mouse (*Perognathus apache gypsi*) which occurs here was first found by an expedition from the University of Michigan in 1927, when 5 specimens were collected (Dice, 1929, 1–4). A large number of specimens were later collected by Alexander, Kellogg, and Benson of the California Museum of Vertebrate Zoology, in September and October 1931 (Benson, 1933, 26–30).

Tularosa Malpais. A large area of nearly black lava lies in the northern part of the Tularosa Basin, mostly in Lincoln County, New Mexico (Benson, 1933, 13–16). The total area covered by this lava is about 120 square miles. Its lower portion is only a few miles from the White Sands and at the same altitude. The elevation of this lava bed is about 4100 feet above sea level, a height considerably above that of the lava beds studied in Arizona and Sonora, and the vegetation also is quite different, consisting of low cacti of several types, mesquite, and other shrubs. Nevertheless, the type of dark coloration developed by the rock-inhabiting rodents is strikingly similar in general, though different in detail, to that developed by certain of these same rodent species on rocks of similar color several hundreds of miles to the westward.

An expedition from the University of Michigan first studied the mammals of this lava bed in 1927 (Dice, 1930, 12–13). G. W. Bradt (1932, 321–328) collected here during two later summers, in 1928 and 1929, and Alexander, Kellogg, and Benson collected for the California Museum of Vertebrate Zoology in September and October 1931 (Benson, 1933, 3–4).

Kenzin lava beds. "The lava beds near Kenzin are portions of an extensive series of flows covering the plain on the south side of the Rio Grande Valley" (Benson, 1933, 17). Alexander and Kellogg of the California Museum of Vertebrate Zoology collected on these lava beds October 24 to 26, 1931. The Kenzin lavas have not been studied by either of us.

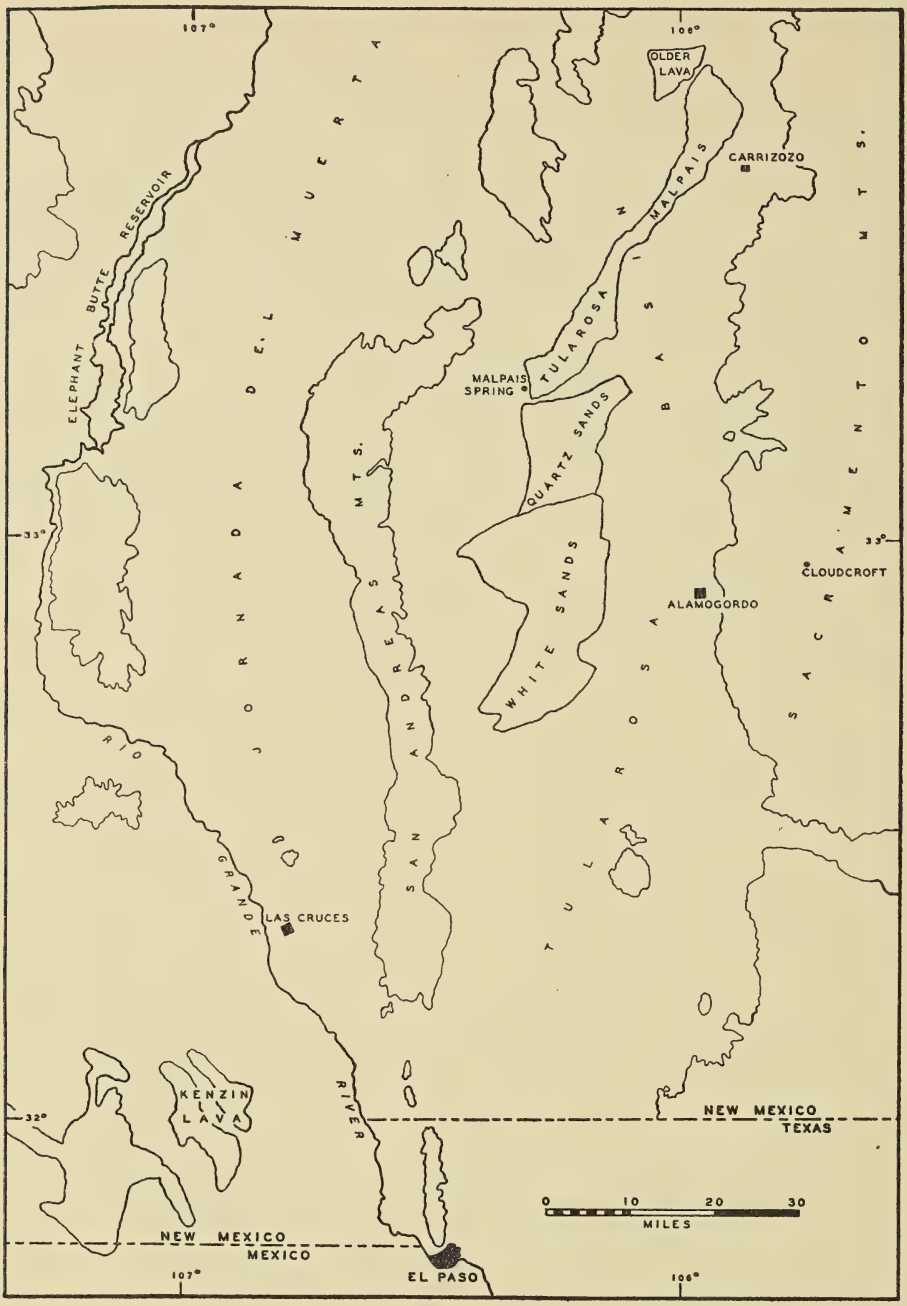

FIG. 3—Map of part of southern New Mexico, based on maps of the United States Geological Survey and of various authors.

ANNOTATED LIST OF MAMMALS

This list makes no attempt to include all the species of mammals occurring in the regions studied. There is included in general only original information

about the species which we encountered and about those reported by persons whom we believe to be reliable. Previously published records of other authors are in general not repeated here, except of a few forms which we did not secure and of several habitat records supplementing our own observations. W. H. Burt has kindly given us a number of habitat records which amplify his published (1933) report on southern Arizona. For scientific names we have followed in general Miller's *List of North American Recent Mammals* (1923), except for forms described subsequently, for which we append the describer's name.

Sorex vagrans monticola. Rocky Mountain shrew. One specimen was taken by Doutt (1934, 251) near Soldier Camp, Santa Catalina Mountains.

Notiosorex crawfordi crawfordi. Desert shrew. Blossom (1933c, 70) secured a specimen at 6500 feet elevation in Pinery Canyon, Chíricahua Mountains. This specimen had been picked up by a resident in a loamy cultivated field close to a stream.

Macrotus californicus. Leaf-nosed bat. Dice secured a single specimen 9 miles north of Tucson on April 11, 1930. This bat was flying about the residence of D. T. MacDougal during the early evening, and when the electric lights in the garage were lighted about 9:00 p.m. the bat flew inside and hung up on a rafter. The location is on the upper bahada, about 1 mile south of the base of the Santa Catalina Mountains.

On February 5, 1932, Blossom collected 76 individuals 200 feet below the surface in the drifts of the Yuma Mine, which is located in the Tucson Mountains 10 miles northwest of Tucson. When disturbed these bats became very active, and all the specimens were taken in the air. The caretaker at the mine said that the bats were active in the drifts through the entire winter, but that he had never seen them outside during the cooler weather. He stated that when the weather was dry the bats came to the higher levels of the mine, and during rains they descended to the deeper drifts. This statement seemed substantiated by the fact that the day before these specimens were collected there had been a hard rain, and no bats were seen above the 200-foot level, although the drifts above this depth were well investigated.

Myotis velifer velifer. Cave bat. Reported by Burt (1933, 115) from Continental and from Tumacacori Mission on the Santa Cruz River, and from Madera Canyon, Santa Rita Mountains.

Myotis volans interior. Little brown bat. Two were shot by Dice on the evening of June 22, 1932, as they were flying among the trees in the bottom of Sabino Canyon at his camp near Summerhaven, Santa Catalina Mountains.

Pipistrellus hesperus hesperus. Canyon bat. One was shot by Dice on the evening of March 24, 1930, at Verrugo Pass, 50 miles northeast of Libertad, Sonora.

Pipistrellus hesperus merriami. Canyon bat. An adult male was shot by Dice in the early morning of July 25, 1932, as it was flying about in the open growth of oaks on the alluvial fan at the mouth of Miller Canyon, east base of the Huachuca Mountains. This bat weighed 4.0 gm. We

follow Burt (1933, 115) in referring specimens from southeastern Arizona to the subspecies *merriami*.

[Two canyon bats were shot by Blossom on March 19, 1931, as they were flying in Fresnal Canyon, Baboquivari Mountains. Three others were shot in the spring of 1931 at the mouth of Sabino Canyon, Santa Catalina Mountains. These bats were not preserved, and therefore cannot be allocated as to subspecies.]

Eptesicus fuscus pallidus. Large brown bat. One was shot by Dice June 24, 1932, as it was flying among the trees in the bottom of Sabino Canyon below Summerhaven, Santa Catalina Mountains. Two others were shot July 14 about 8 miles southeast of Oracle as they were flying among the sycamore and walnut trees in the bottom of Peppersauce Canyon.

Lasiurus borealis teleotis. Red bat. Three were shot by Dice on the evenings of July 11 and 14, 1932, as they were flying at the edge of the sycamore association in Peppersauce Canyon, 8 miles southeast of Oracle.

Ursus americanus subspecies. Black bear. Mr. Dusenberry, a resident, told Blossom in 1931 that an occasional black bear occurs in the Santa Rita Mountains.

Procyon lotor subspecies. Raccoon. Part of a skeleton was found by Dice in June 1932 outside a burrow beneath a large boulder in yellow pine association at 7700 feet elevation in Sabino Canyon, Santa Catalina Mountains, a short distance below Summerhaven. During the same month fresh tracks were seen along the stream.

Bassariscus astutus arizonensis Goldman. Bassarisk. Four were trapped by Blossom between January 5 and February 18, 1931, between 5200 and 5800 feet elevation, in Madera (White House) Canyon, Santa Rita Mountains. All were taken among the rocks in the bottom of the canyon in sycamore association.

Blossom trapped 2 in February and March 1931 in the attic of the Carnegie Desert Laboratory on Tumamoc Hill, Tucson. A number of these animals lived on this rocky hill and had become quite tame. They could often be seen at dusk when they came out of a hole which led to the outside of the building. Once one was seen at about 3:00 p.m. outside the building. Six skins were seen which had been taken in the Rincon Mountains, the name given to the southeastern part of the Santa Catalina Mountains.

Percy Leaverton, forest ranger, reported in 1932 that this animal probably occurs sometimes in the montane belt on the Santa Catalina Mountains and is numerous in the oak belt.

Walter P. Taylor reports that it is common in Pinery Canyon in the Chíricahua Mountains.

Spilogale gracilis gracilis. Spotted skunk. Reported common near Soldier Camp, Santa Catalina Mountains, by Doutt (1934, 252).

Spilogale species. Spotted skunk. One was killed March 13, 1930, by Dice on Tumamoc Hill inside the main building of the Desert Laboratory, which it had entered from the surrounding rock hill association. Tracks

almost certainly of the spotted skunk were numerous in 1930 in sahuaro, ocotillo, and palo verde on the upper bahada, 9 miles north of Tucson, and not far from the mouth of Pima Canyon, Santa Catalina Mountains.

One was trapped by Blossom February 20, 1931, at 5300 feet elevation in sycamore association in the bottom of Madera Canyon, Santa Rita Mountains, and 3 dried skins were examined of specimens taken in the same locality by a resident. Another was trapped by Blossom March 14, 1931, in the attic of the Desert Laboratory.

Several of the described species of *Spilogale* might occur in the Tucson region, but some or all of these described forms will probably prove to be subspecies or synonyms, and we have made no attempt to assign our specimens to a particular species.

Mephitis estor. Striped skunk. Blossom trapped 2 in April 1931 at 8200 feet elevation, under a building in yellow pine forest in Rustler Park, Chíricahua Mountains. Three were taken in 1931 in sycamore association at elevations of 5000 to 6000 feet along the bottom of Madera Canyon, Santa Rita Mountains. Four skins, from animals trapped in this canyon by other persons, were also examined. In Madera Canyon the three genera of skunks, *Spilogale*, *Mephitis*, and *Conepatus*, occur together in the sycamore association.

One came during the night of June 12, 1932, into Dice's camp, elevation 7500 feet, in Sabino Canyon, near Summerhaven, Santa Catalina Mountains. She was trapped in streamside association, but was also noted in yellow pine forest. This adult female was in milk. The mammæ totaled 7 on the right side and only 5 on the left side, the arrangement being: pectoral, 3 right and 3 left; abdominal, 2 right and 1 left; and inguinal, 2 right and 1 left. Under the skin of the shoulder there was a nest of long nematodes.

Conepatus mesoleucus venaticus. Hog-nosed skunk. In 1931 Blossom took 5 at 5000 to 5600 feet elevation in sycamore association among the rocks along the bottom of Madera Canyon, Santa Rita Mountains.

Percy Leaverton, forest ranger, in 1932 reported it to occur in the upper parts of the Santa Catalina Mountains.

Taxidea taxus berlandieri. Badger. Doutt (1934, 253) took a young male at Peppersauce Canyon.

Vulpes macrotis subspecies. Desert fox. One was seen by Blossom in 1931 and one in 1932, both on the rocky slopes of Tumamoc Hill, Tucson.

Urocyon cinereoargenteus subspecies. Gray fox. Percy Leaverton, forest ranger, stated in 1932 that the gray fox occurs in the upper Santa Catalina Mountains. Feces, probably of this species, were found by Dice in June 1932 on top of a rock on a yellow pine slope at an elevation of 7700 feet, above Sabino Canyon, Santa Catalina Mountains. These feces contained much hair of the rock squirrel and wood rat, but no bones.

Canis latrans subspecies. Coyote. In early April 1930 Dice noted a few tracks and feces in mesquite forest association and in creosote bush association about 5 miles northwest of Robles Ranch. On April 11, feces, probably of

this species, were noted in upper bahada association about 9 miles north of Tucson. One was heard in July 1932 at night by Mrs. Dora Dice at the Peppersauce Canyon camp, 8 miles southeast of Oracle. Mr. Daley, an old resident, says that a few still occur along the San Pedro River near Mammoth.

One was seen by Blossom in September 1932, crossing the highway 30 miles north of Hot Springs, New Mexico. Another was observed in 1932 on the highway 10 miles north of Deming, New Mexico. One was seen in May 1933, 20 miles east of Tule Tank in Yuma County, Arizona, on the Pinacate lava plain. It was reported in 1931 by residents at Continental, 20 miles south of Tucson, to be common in that vicinity.

Felis concolor subspecies. Cougar. Reported in 1930 by residents of Rodeo, New Mexico, as common a few years ago in the Chíricahua Mountains, but now less abundant because of extensive hunting with dogs. Mr. Dusenberry, a resident in Madera Canyon, stated in 1931 that cougars were rare in the Santa Rita Mountains.

In June 1932 a young cougar was killed near Soldier Camp in the Santa Catalina Mountains. It was also reported by residents that a large cougar had been killed several years previously in Sabino Canyon near Summerhaven. A cougar was said, by one of the cowboys of the 3C Ranch, to have killed a deer in Peppersauce Canyon near Oracle during June 1932.

Lynx rufus subspecies. Bobcat. A skull was found by Blossom in 1931 at 4000 feet elevation near Florida Ranger Station, west of the Santa Rita Mountains, in grass–mesquite association. Mr. Dusenberry, of Madera Canyon, states that there are few bobcats in the Santa Rita Mountains. Percy Leaverton, forest ranger, stated in 1932 that a few bobcats occur in the higher parts of the Santa Catalina Mountains.

Citellus grammurus grammurus. Rock squirrel. In 1930, 3 were trapped by Harris and Dice on the rocky slopes of Tumamoc Hill, Tucson, near the Desert Laboratory, where it was numerous.

Several were seen by members of the Desert Laboratory party in March 1930 on rocky hills at Verrugo Pass, 50 miles northeast of Libertad, Sonora, and a weathered skull was secured by Dice.

In February 1931 Blossom took 3 at 5000 to 5800 feet elevation, alongside large rocks at the edge of sycamore association on the sides of Madera Canyon, Santa Rita Mountains. There was much evidence of this species among the rocks in the encinal belt on the sides of this canyon. Two were shot the same year in Cave Creek Canyon in the Chíricahua Mountains, at elevations of 5000 to 7200 feet. Two were seen in March 1931 along the Santa Cruz River, 10 miles south of Tucson, in small cottonwood trees, where they apparently were eating leaves or buds.

One was seen by Blossom in March 1931, at 3000 feet elevation, on rocks in Fresnal Canyon, Baboquivari Mountains. None were seen on either the Pinacate Mountains or the smaller desert ranges of southwestern Arizona.

In the upper Santa Catalina Mountains a few occur wherever there are rocks, and Dice in 1932 trapped 6 around boulders in yellow pine association

near Summerhaven; 1 was seen in oak brush, 1 in streamside association in the bottom of Sabino Canyon, and 1 under a cabin. A number were seen in the encinal belt on the north slope of the mountains along the automobile road. It was numerous in sycamore association in the bottom of Peppersauce Canyon, 8 miles southeast of Oracle, and also in a thick growth of mesquite on the adjacent springy canyon side to the northwest; 1 was seen on a nearby rocky slope dominated by ocotillo. Three were seen on the tops of large boulders in the open oaks of the lower part of the encinal belt near Oracle, and 1 in mesquite–grass association 6 miles southeast of Oracle. At the mouth of Miller Canyon, Huachuca Mountains, its burrows were common in 1932 in the gravelly soil of the alluvial fan in open oak plain forest, and it was also numerous on the adjacent oak-covered rocky lower mountain slopes. One was taken in *Senecio* association at the same place.

The lens of the eye of this squirrel is quite yellow in color, a probable adaptation, according to the interpretation of Walls (1931, 127), to its diurnal habits and the brilliant light of its habitat.

A female taken by Dice on June 14, 1932, near Summerhaven was suckling. On July 17, 1932, about 9 miles southeast of Oracle, Dice saw an adult carrying a nearly hairless young. The mammæ are 1 pair pectoral, 2 pairs abdominal, and 2 pairs inguinal.

Citellus spilosoma canescens. Spotted spermophile. One was trapped by Dice in June 1932 in catclaw–mesquite association along the San Pedro River at Hereford. At the mouth of Miller Canyon, Huachuca Mountains, one was secured in *Senecio* association, and at the mouth of the adjacent Hunter Canyon another was seen in an open stand of oak, "bear grass" (*Nolina*), and short grass. Although Oracle is the type locality of *Spermophilus spilosoma macrospilotus*, a synonym of *canescens*, we failed to find the species near Oracle. The scarcity of these squirrels in southern Arizona is probably due to extensive rodent-poisoning campaigns carried out in recent years.

This squirrel is said by Mearns (1907, 333) to have two color phases, buff and gray. The two specimens taken by Dice at the eastern base of the Huachuca Mountains and near Hereford are both buff in color.

Citellus tereticaudus neglectus. Round-tailed spermophile. Widely distributed in the Tucson region. It lives on the sandy soils of the desert plains and none were observed on the rocky slopes of the desert mountains.

During March 1930 Harris trapped 2 on upper bahada slopes on the western edge of the Tortollita Mountains, 9 miles north of Rillito. He also shot 3 at the mouth of Sabino Canyon, 15 miles northeast of Tucson, in a small basin where mesquite was dominant and where cholla and barrel cactus were numerous. We are uncertain to which ecological association this record should be assigned. The same spring Dice secured 5 in grass and mesquite on the Santa Rita Range Reserve and saw 1 in creosote bush association near Robles Ranch, 25 miles west of Tucson. In late March 1930 Harris and Dice collected specimens at the following localities in Sonora: 1 at Verrugo

Pass, 50 miles northeast of Libertad; 1 at a point 3 miles south of Verrugo Pass; and 1, 20 miles north of Altar.

In 1931 Blossom took 12 in grass and mesquite on the Santa Rita Range Reserve; 2 in *Isocoma* association 25 miles south of Tucson; 1 in cottonwood–willow association on the Rillito Wash near Fort Lowell; 1 in creosote bush 2 miles west of Tucson; 1 in creosote bush 5 miles north of Tucson; 13 in cholla–mesquite–hackberry association 10 to 16 miles south of Tucson. In the same year he took 1 in Fresnal Canyon, Baboquivari Mountains.

The round-tailed spermophile is active all winter in the Tucson region, although on cool days very few are seen above the ground.

Three adult males taken on March 21, 1930, by Harris and Dice, about 20 miles south of Tucson all had enlarged testes. Three of the females taken April 1, 1930, on the Santa Rita Range Reserve contained small embryos, one 4, one 5, and the other 6.

Ammospermophilus harrisii harrisii. Antelope squirrel. This is the most conspicuous small diurnal mammal of the desert plains from Tucson to the Colorado River, occurring in many types of habitat, but with a spotty distribution.

Harris and Dice shot 2 on March 15, 1930, about 20 miles south of Tucson, on sandy soil dominated by mesquite, palo verde, grass, and cholla cactus. The precise location of this place is but vaguely described in our notebook, for we stopped off here for only a short time during an all-day trip. We therefore have not attempted to assign this record to a particular ecological association.

During April 1930 Dice trapped 9 in upper bahada association, 9 miles north of Tucson. At this place the animals seemed to be colonial, for a number were secured in a small area, while elsewhere on the upper bahada the species was rare or absent. One individual was trapped on rocky ledges at the mouth of Pima Canyon, 10 miles north of Tucson, and another was seen among the rocks which partially cover a small hill on the upper bahada about $9\frac{1}{2}$ miles north of Tucson.

Between December 1930 and March 1931, Blossom took 1 in grass and mesquite on the Santa Rita Range Reserve, where many were observed; 7 between 10 and 16 miles south of Tucson in cholla–mesquite–hackberry association, where many were seen and burrows were numerous around clumps of desert hackberry; 1 in creosote bush association 5 miles north of Tucson; 2 in rock hill association in the Tucson Mountains, 4 miles west of Tucson; and 1 on the rocky ledges of Pima Canyon.

It was numerous in July 1932 in mesquite and grass 6 miles southeast of Oracle, and Dice took 1 specimen. This was at an elevation of 4400 feet, the highest point on the northern slopes of the Santa Catalina Mountains at which the species was noted. Two were seen by Dice in palo verde–mesquite–grass association at 3750 feet elevation, 5 miles north of Oracle.

Burt reports the species present in 1931 in mesquite forest association at Continental.

A female taken by Harris about 20 miles south of Tucson on March 15, 1930, contained 5 embryos, each about 15 mm. in length. A male taken near the same place on March 21 had the testes greatly enlarged. A female taken by Dice 9 miles north of Tucson, on April 16, 1930, was in milk but contained no embryos. An adult male was taken in an adjacent trap. A female taken by Blossom April 17, 1931, 10 miles south of Tucson, also was nursing.

The testes of the adult males taken near Tucson in middle April 1930 were all very large, and the animals were in breeding condition. Many of the females were at this time already nursing and it therefore seems possible that a second brood may be reared during the same season.

A vaginal plug probably is formed after copulation in this species. The adult males taken in April extruded at death a large amount of sticky fluid from the penis, and this fluid soon hardened into a very hard mass. The penis of *Ammospermophilus* is very large and fleshy.

Ammospermophilus harrisii saxicola. Antelope squirrel. Swarth (1929, 351) compared 14 adult specimens of *Ammospermophilus harrisii harrisii* from the vicinity of Tucson with 24 comparable adults of supposed *A. h. saxicola* from the lower Colorado River. He agreed with Grinnell (1914, 220) in finding no appreciable differences either in color or in measurements between the two races. Consequently he concluded that *saxicola* is not deserving of recognition. This conclusion was questioned by Doutt (1934, 257). We have compared 12 specimens from the vicinity of Tucson with 10 specimens from Tinajas Altas (type locality of *saxicola*) and from other light-colored granite mountain ranges in southwestern Arizona and northwestern Sonora. In measurements we do not find the differences ascribed by Mearns (1907, 307–309) to the two forms, but the specimens from southwestern Arizona and northwestern Sonora are clearly distinguished by their paler coloration, which is especially pronounced over the head, neck, and shoulders.

Harris and Dice collected the following specimens in Sonora during late March 1930: 1 at Picu Pass, 20 miles east of Libertad; 1 at a point 4 miles north of Cerna or about 45 miles northeast of Libertad; 1 at a point 10 miles northeast of Verrugo Pass or about 60 miles northeast of Libertad.

Blossom in October 1932 collected 2 among the rocks at Tule Tank; 1 on rocky slopes at Tinajas Altas; 1 on upper bahada slopes at the base of the Cabeza Prieta Mountains 9 miles north of Tule Tank; and 3 in creosote bush on the desert plain near Raven Butte. On April 24, 1933, he took 3 in rocky habitats 25 miles west of Sonoyta, Sonora.

A female taken April 24, 1933, about 25 miles west of Sonoyta was suckling. Like *harrisii*, this form has 6 pairs of mammæ.

A family of young was seen by Dice in Picu Pass, about 20 miles east of Libertad, Sonora, on March 27, 1930, near the water holes which occur about 3 miles north of the road. At least three half-grown young were in this group, one of which was secured as a specimen. The young animals were running about over a pile of rocks beside the rocky gorge in which the water

holes lie, and about 100 feet downstream from the lowest water hole. Numerous tunnels ran under the rocks where the squirrels were playing and abundant deposits of feces lay at the entrances to some of the tunnels.

Eutamias dorsalis dorsalis. Cliff chipmunk. Six were taken by Blossom among large boulders in yellow pine forest on April 17 and 18, 1931, at 7600 and 8200 feet elevation in the Chíricahua Mountains. This species is abundant around the Boy Scout Camp in Rustler Park.

It is common throughout the forested belts of the Santa Catalina Mountains. Its range extends to the top of Mount Lemmon, where it was said by the forest lookout to be a pest at the lookout cabin. A few occur in the oak forests at Peppersauce Canyon, 8 miles southeast of Oracle. This location, elevation 4600 feet, was the lowest point at which it was seen. Altogether 60 individuals were trapped by Dice in 1932, mostly in live traps, and many more were seen. It occurs in all the associations of the montane belt: Douglas fir, yellow pine, streamside, oak brush, and rock cliff; and in the encinal belt was taken in the oak association.

Males taken June 7 and June 11, 1932, near Summerhaven, had enlarged testes, and females taken at the same place between June 9 and 14 were suckling. Several immature individuals were taken on June 15 and on later dates. The mammæ are 1 pair pectoral, 1 pair abdominal, and 2 pairs inguinal.

The lens of the eye is distinctly yellowish in color, but is less deeply colored than that of the rock squirrel. This would be expected, since the chipmunk lives in less exposed habitats than the rock squirrel.

Sciurus arizonensis catalinæ Doutt. Arizona squirrel. Although protected by law, only a few of these squirrels occur in the upper parts of the Santa Catalina Mountains. In June 1932 Dice saw 4 in yellow pine forest near Summerhaven and Soldier Camp, at elevations of 7500 to 7800 feet. One was seen on a north slope near Soldier Camp in a mixed forest, mostly of fir and Douglas fir but containing some yellow pine. Another was seen in mixed yellow pines and oaks at about 7000 feet elevation on the north slope of the mountains. Residents report that when the acorns are ripe in summer the squirrels migrate far down into the oak belt.

The mammæ of one adult female taken were 1 pair pectoral, 1 pair abdominal, and 1 pair inguinal.

The lens of the eye is yellowish in color, but is slightly paler than that of the rock squirrel.

Sciurus arizonensis huachuca. Arizona squirrel. Three were seen by Dice in 1932 at elevations from 5200 to 5800 feet, in Miller Canyon, Huachuca Mountains, all in the sycamore association. A young one collected on July 27 was over half-grown. The Museum of Zoology of the University of Michigan has also 2 specimens from elevations of 6000 and 6300 feet in Bear Canyon on the western slope of the Huachuca Mountains. These specimens were taken by E. C. Jacot on June 5, 1933.

Thomomys bottæ catalinæ Goldman. Valley pocket gopher. In the

bottom of Sabino Canyon near Summerhaven mounds made by pocket gophers were numerous in June 1932, and 4 individuals were trapped by Dice in streamside association. On the adjacent yellow pine slopes no mounds were seen. A few mounds were seen in Douglas fir forest on the north slope of Mount Lemmon at an altitude of about 8500 feet, and other mounds were noted in a mixed growth of aspens and pines nearly at the summit of Mount Lemmon.

The cheek pouches of an adult female taken June 12, 1932, near Summerhaven, contained two pieces of dry yellow pine needles, one 21 mm. and the other 23 mm. long. The animal was held in the trap in such a manner that these needles must have been in the pouches before she was caught.

Thomomys bottæ collinus Goldman. Valley pocket gopher. Two were taken by Blossom in 1932 in a meadow at 8700 feet elevation, in Rustler Park, Chíricahua Mountains.

Thomomys bottæ modicus Goldman. Valley pocket gopher. This subspecies is said by Goldman (1931a, 418–419) to inhabit the "desert plains and valleys of central southern Arizona, and probably adjoining parts of Sonora, Mexico." Specimens are reported by Goldman from Fort Lowell and Tucson. Burt (1933, 117–118) reports the species common at Tucson and at Tumacacori Mission, but absent along the Santa Cruz River near Continental.

We assign to this subspecies 3 specimens in the California Institute of Technology which were taken by Burt on April 30, 1933, in a mesquite wash in Fresnal Canyon, Baboquivari Mountains, just below Allison Dam.

Pocket gopher mounds were noted in 1930 by Harris and Dice on the lower desert at several places along the route from Sasabe to Libertad, Sonora, but only one specimen was secured. About 5 miles east of Pitiquito on the morning of March 24, a pocket gopher was discovered, by a botanist of our party, actively working in bright sunlight at about 9 o'clock. The opening of the burrow was at the base of a brittlebush (*Encelia*) and the animal was feeding on the stems and bark of the shrub. Stems up to an estimated diameter of 7 mm. were cut off and some missing sections had evidently been carried away by the animal. From larger stems the bark had been gnawed away. Old healed scars on the shrub and on the cut stumps of stems showed that the same animal or another had at some previous time fed upon the same shrub. The animal was quite nervous and when we were near would come only part way out of the burrow and then jerk back out of sight. Finally she was caught in a snap rat trap, which unfortunately broke the skull. Although the specimen differs somewhat in color from *modicus* from the vicinity of Tucson, we assign it to that subspecies.

Thomomys bottæ extenuatus Goldman. Valley pocket gopher. On the buff-colored soil at the mouth of Miller Canyon, Huachuca Mountains, mounds were numerous in July 1932, and Dice trapped 2 pocket gophers in oak plain association and 1 in *Senecio* association. The close correlation between the soil color at this place and the buffy pelage color of the animals is quite remarkable.

Perognathus flavus flavus. Baird pocket mouse. In 1930 one was trapped by Blossom at Fort Lowell, 7 miles northeast of Tucson, in cottonwood–willow association. This pocket mouse seems to be rare at Tucson, but Burt (1933, 118) secured 14 specimens at Continental. Four specimens were secured by Dice in late July 1932 in *Senecio* association at the mouth of Miller Canyon, Huachuca Mountains.

Perognathus amplus rotundus Goldman. Bahada pocket mouse. One was taken by Blossom April 25, 1933, on the desert plain near Papago Tanks, Sonora. Another was trapped May 5, 1933, on gravelly slopes at Tule Tank, Arizona.

Perognathus amplus taylori Goldman. Bahada pocket mouse. This mouse is most common on the sandy soils of the lower desert, and it was not taken above 4000 feet elevation. In 1930 Dice trapped 5 near Robles Ranch, 25 miles west of Tucson, elevation about 2500 feet, in creosote bush association, which in some places was mixed with some catclaw and mesquite. Three were trapped at about 2700 feet elevation 8 miles north of Tucson, on soil composed of sand and small gravel, and in vegetation dominated by palo verde and brittlebush; and 2 were taken at an elevation of 2900 feet, 9 miles north of Tucson on gravelly and rocky upper bahada slopes at the base of the Santa Catalina Mountains, near the mouth of Pima Canyon.

Three were taken by Blossom April 11, 1932, in creosote bush association, near Fort Lowell, 8 miles northeast of Tucson.

In 1932 one was trapped by Dice on a gravelly slope at an elevation of 3750 feet 5 miles north of Oracle, in palo verde–mesquite–grass association.

Burt reports it from the sandy bottoms of desert washes near Continental.

The common name bahada pocket mouse here used refers to the common occurrence of this species on the desert bahadas, the slopes which surround the bases of the desert mountains.

Perognathus baileyi baileyi. Bailey pocket mouse. This large pocket mouse is numerous on the rocky upper parts of the bahadas around the desert mountains near Tucson, but it is rare on the sandy soils of the lower desert. Its range extends upward to include the grassland belts on the western side of the Santa Rita Mountains and on the northern side of the Santa Catalinas. The highest elevation at which it was taken near Oracle was 4700 feet.

In 1930, Dice took 1, 5 miles northwest of Robles Ranch in modified mesquite forest association; 2 at 2650 feet elevation, 8 miles north of Tucson, in a gravelly and sandy wash among catclaw and mesquite; 5 on sandy soil at 2700 feet, 8 miles north of Tucson, in palo verde–brittlebush association; 18 on rocky and gravelly soil at 2900 feet, 9 miles north of Tucson, on the upper bahada dominated by giant cactus, palo verde, and ocotillo; and Dice and Harris took 2 in similar upper bahada association at the west base of the Tortollita Mountains, 10 miles north of Rillito.

Blossom in 1930 and 1931 took 8 at 4300 feet elevation near the mouth of Madera Canyon, Santa Rita Mountains, in grass and mesquite; 6 in creosote

bush near Fort Lowell; 3 at the northeastern base of the Tucson Mountains, 4 miles west of Tucson, on upper bahada slopes; and 1 on the rocky slopes of Black Mountain, 10 miles south of Tucson. In 1932 he took 1 on the rocky slopes of Tumamoc Hill, Tucson. In 1933 he took 1 specimen on the gravelly slopes of Elegante Crater, Pinacate Mountains, Sonora.

Dice in 1932 took 1 at 4500 feet elevation in the lower edge of the encinal belt, 3 miles southeast of Oracle, in an open growth of oak and "bear grass" (*Nolina*); 5 on a "mesa" at 4600 feet, just within Pima County, 10 miles southeast of Oracle, in mesquite and grass; 4 at 4400 feet, 6 miles southeast of Oracle, in mesquite–grass association; 3 at 4000 feet, $2\frac{1}{2}$ miles north of Oracle, in a sandy wash among oaks and catclaw; 3 at 4700 feet, near Peppersauce Canyon, 8 miles southeast of Oracle, on a rocky slope in ocotillo association; and 29 at 3750 feet, 5 miles north of Oracle, at the lower edge of the grassland belt, in palo verde–mesquite–grass association.

Burt took it in 1931 in mesquite forest association at Continental.

The mammæ are 1 pair pectoral and 2 pairs inguinal. Two females with enlarged mammæ indicating the nursing of young were taken by Blossom April 11, 1931, near Fort Lowell, and two pregnant females were taken on the same date, one female containing 4 embryos and the other 5. A female taken by Dice July 17, 1932, 10 miles southeast of Oracle contained 6 small embryos.

Perognathus baileyi domensis Goldman. Bailey pocket mouse. One specimen was taken by Blossom October 25, 1932, on a rocky slope at Tinajas Altas.

Perognathus hispidus paradoxus. Plains pocket mouse. Two were trapped by Dice during July and August 1932 at the mouth of Miller Canyon, Huachuca Mountains, at an elevation of 5000 feet, in *Senecio* association; 1 was taken among clumps of tall grass along the San Pedro River at Hereford, elevation 4100 feet; and 1 was taken about 100 feet higher and a mile farther west in *Yucca* association.

Perognathus penicillatus pricei. Sand pocket mouse. The sand pocket mouse occupies the more sandy and gravelly habitats throughout the regions studied and is almost never found on rocky slopes unless rather extensive sandy spots occur between the rocks. One was taken by Harris and Dice in 1930 in an open growth of mesquite and grass beside a sandy wash, about 2 miles south of Sasabe, Sonora, just a short distance south of the Arizona line. It was common in 1930 on sandy areas near Robles Ranch, about 25 miles west of Tucson, where 30 were taken by Dice in modified mesquite forest association, and 16 in creosote bush association. Eight were taken in desert wash association along a sandy and gravelly arroyo 8 miles north of Tucson.

Two specimens, represented by skulls, taken by Dice in 1930 on rock hill association at the mouth of Pima Canyon, 10 miles north of Tucson, have been identified by S. B. Benson as being of this species, although he states that they are not typical. The occurrence of this species in the rock hill association at this place is quite a surprise, for elsewhere in the region *penicillatus*

is restricted to the more sandy situations. It was not taken on the upper bahada immediately adjacent to the rock hill habitat at Pima Canyon, though it does occur along a sandy wash about 1 mile distant. We did not trap in the arroyo coming from Pima Canyon, but some sandy spots occur along this arroyo and in these sandy situations the sand pocket mouse would likely occur. It is possible, therefore, that the sand pocket mice found on the rocky slopes at the mouth of Pima Canyon may have been wanderers from the nearby Pima arroyo.

In 1931 Blossom took 4 near Fort Lowell, in cottonwood–willow association bordering Rillito Wash; 6 about 10 miles south of Tucson in cholla–mesquite–hackberry association; 9 near Fort Lowell, about 8 miles northeast of Tucson, in creosote bush association; and 2 in Fresnal Canyon, Baboquivari Mountains, near Allison Dam.

In the Pinacate Mountains in 1933 Blossom trapped 1 at Elegante Crater, on the volcanic slopes dominated by creosote bush and *Encelia farinosa*; 7 in creosote bush on the cinder slopes below Papago Tanks; and 1 in the margin of the main Pinacate lava flow near Elegante Crater, or about 41 miles west of Sonoyta. At the place where this last-mentioned specimen was taken the edge of the lava is penetrated by many tongues of desert sand, and it is possible that this specimen, which is of the usual pale gray color, was taken on one of these small strips of sand.

Two specimens out of 7 taken on the dark-colored sands at Papago Tanks and the one taken on the Elegante Crater are decidedly dark in general color tone. Because of the small series of specimens of this species available from the Pinacate district, a critical study of the color variability cannot be made. However, it is interesting to note that the sand pocket mouse, in this area where the soil is covered by a layer of blackish sand, shows a strong tendency toward dark pelage color.

Dice trapped 3 in 1932 beside the San Pedro River at Hereford, among the clumps of tall grass in sacaton association, and 3 in mesquite–catclaw association. Two were taken on sandy soil in *Yucca* association, 1 mile west of Hereford; and 1 in *Senecio* association at 5000 feet elevation on the alluvial fan at the mouth of Miller Canyon, Huachuca Mountains.

The number of mammæ is 1 pair pectoral and 2 pairs inguinal. A nursing female was taken by Blossom near Fort Lowell on April 11, 1931, and 4 other nursing females were taken at Papago Tanks on April 25, 1933.

Perognathus intermedius intermedius. Rock pocket mouse. The rock pocket mouse is probably the most abundant mammal in the deserts of southern Arizona and northern Sonora. It is closely restricted to the rock hill association, and wherever rocks are found this species is usually present in considerable numbers. The species is represented in this region by several pale and several dark-colored races, of which the subspecies *intermedius* has the most extensive range.

In 1930 Harris and Dice trapped 24 at the western edge of the Tortollita

Mountains, 10 miles north of Rillito, on rocky slopes covered with ocotillo, sahuaro, and palo verde; and 3 on adjacent rocky, upper bahada association, dominated by the same plants, only a few hundred feet from the base of the mountains. Dice trapped 12 the same year on rock ledges at the mouth of Pima Canyon, Santa Catalina Mountains, about 9 miles north of Tucson. Another was taken in a steep-sided rocky and sandy wash 8 miles north of Tucson and about ½ mile from the base of the mountains. This is the greatest distance away from rock-covered mountain slopes that any were taken.

Blossom in 1930 and 1931 trapped 2 on the rocky northeastern slopes of the Tucson Mountains, 4 miles west of Tucson; 6 at the mouth of Pima Canyon, Santa Catalina Mountains; and 3 in Fresnal Canyon, Baboquivari Mountains. In 1932 he trapped 13 in Javelina Canyon, Tortollita Mountains; 26 in the Agua Dulce Mountains, 9 miles east of Papago Well; 4 on the northwestern border of the Cabeza Prieta Mountains; 31 on the adjacent Crow Butte; 4 in the Wellton Hills; and 20 in Telegraph Pass, Gila Mountains. In 1933 he took 7 at Tule Tank.

In July 1932 Dice trapped 1 at 4500 feet elevation, 3 miles southeast of Oracle, among rocks in open oak forest; 3 at 4700 feet, 8 miles southeast of Oracle, on the south-facing side of Peppersauce Canyon, on rocky ground dominated by ocotillo; and 5 at 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association. Six were trapped at 5100 feet, at the mouth of Miller Canyon, Huachuca Mountains, on rocky, oak-covered slopes.

The description by Goldman (1918, 22–23) of *phasma* was based on two specimens from Tinajas Altas (type locality) and one specimen from Tule Well (3 miles east of Tule Tank). In our series of 7 specimens from Tule Tank there are a few individuals which are as pale in color as some of those from Tinajas Altas, but the Tule Tank series averages darker and is close in color to typical *intermedius*.

Perognathus intermedius nigrimontis Blossom. Rock pocket mouse. This dark-colored race is known only from Black Mountain, 10 miles south of Tucson (type locality), and from Tumamoc Hill, just west of Tucson (Blossom, 1933a, 1–3). In 1930, 8 were trapped by Dice on the rocky slopes of Tumamoc Hill near the Desert Laboratory. In 1931 Blossom trapped 50 on the south slopes of Black Mountain, and in 1932 he took 30 more on Tumamoc Hill.

A female taken April 7, 1931, by Blossom on Black Mountain had what appeared to be a copulation plug in the vagina, and the uterus showed evidence of developing embryos.

Perognathus intermedius phasma Goldman. Rock pocket mouse. In 1932 Blossom trapped 17 on rocky slopes at Tinajas Altas and 11 on Raven Butte. The specimens at hand indicate that this pale-colored form is restricted to the Tinajas Altas Mountains and the adjacent Raven Butte.

Perognathus intermedius pinacate Blossom. Rock pocket mouse. This

dark-colored race is known only from the blackish lavas of the Pinacate Mountains in northwestern Sonora, and from the northern extension of the Pinacate lava flow into Yuma County, southwestern Arizona.

A total of 70 specimens were taken by Blossom in 1933: at the type locality of Papago Tanks 12 were taken on rocky lava beds and 12 in creosote bush on cinder slopes; at Elegante Crater 5 were taken on the rocky slopes of the crater, 6 on cinder-covered lower slopes of the crater in vegetation dominated by brittlebush (*Encelia*), 3 in creosote bush on the adjacent sandy plain, and 4 on the nearby Pinacate lava; on the Pinacate lava in southern Arizona 28 were taken in rocky situations.

All the specimens taken on the Pinacate lava and on the immediately adjacent plain are dark in color, except one specimen taken on the Pinacate lava in southern Arizona. This one aberrant specimen is similar in color to typical *intermedius* and it may possibly be a migrant from the neighboring mountains, some of which are made up of light-colored rocks (Blossom, 1933b, 5) and are inhabited by the pale-colored race *intermedius*.

The mammæ are 1 pair pectoral and 2 pairs inguinal. Four nursing females were taken by Blossom April 24, 1933, near Elegante Crater, and 5 pregnant females taken on the same date each contained 4 embryos. At Papago Tanks on April 25 and 26, there were taken 6 nursing females and 3 pregnant females. Two of the pregnant females contained 4 embryos each and the other later gave birth to 2 young. It is possible that more than 2 young were delivered by this last female and were lost before their discovery. On the Pinacate lava in southern Arizona 2 nursing females were taken on May 6. The young of this species are evidently born in late April and early May.

Dipodomys spectabilis perblandus Goldman. Banner-tailed kangaroo rat. Two of these large kangaroo rats were taken March 22, 1930, by Harris and Dice in a small valley 2 miles south of Sasabe, Sonora. The locality is only a few miles south of the Arizona line, and the habitat is dominated by an open growth of mesquite, under which there is a rather thick growth of grass, mostly *Aristida*, but with some *Bouteloua*. The grasses were identified by Forrest Shreve. Another specimen was taken by Dice April 1 on the Santa Rita Range Reserve, also in a habitat dominated by mesquite and grass. The prominent mounds of the species were numerous at both localities.

Burt reports the species from the mesquite forest association at Continental.

Vorhies and Taylor (1922, 3, 36) report that in grass and mesquite habitat on the Santa Rita Range Reserve the population of this species averages about 2 per acre. Near Tucson they (p. 8) report a few from the "Covillea belt."

Dipodomys merriami merriami. Merriam kangaroo rat. This species is the characteristic kangaroo rat on the lower desert and is much more common over the whole region than is either of the two other kangaroo rats found in southern Arizona. It occupies sandy habitats from the lower desert up to the upper part of the grassland belt.

In 1930 Harris and Dice trapped 4 in upper bahada association on the western side of the Tortollita Mountains, 10 miles north of Rillito. Two

small kangaroo rats, probably this species, were taken in a small valley about 2 miles south of Sasabe, Sonora, in mesquite and grass, but the specimens were not preserved. Dice found the species numerous on sandy soil 5 miles northwest of Robles Ranch, or about 25 miles west of Tucson, and 4 were taken in modified mesquite forest association and 6 in creosote bush. He took also 1 specimen on sandy soil 8 miles north of Tucson on a soil of sand and small gravel dominated by palo verde trees and brittlebush shrubs. On the Santa Rita Range Reserve 4 specimens were taken in grass and mesquite.

Blossom in 1931 trapped 14 on the Santa Rita Range Reserve, near the mouth of Madera Canyon, in grass and mesquite; 5 on the lower part of the Range Reserve in *Isocoma* association; 5 near Fort Lowell in cottonwood–willow association; 5 about 6 miles south of Tucson in creosote bush association; and 3 in cholla–mesquite–hackberry association, 10 to 16 miles south of Tucson, where burrows were numerous.

In 1932 Dice took 1 in a sandy wash 2½ miles north of Oracle among a growth of oaks, catclaw, sumac, and "bear grass" (*Nolina*). Mounds were numerous at an elevation of 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association, and 1 specimen was secured. Four were trapped by Dice in 1932 at an elevation of 4200 feet, 1 mile west of Hereford, where mounds were common in rather sandy soil in an open stand of thorny shrubs and yucca.

A female taken by Dice, April 8, 1930, 5 miles northwest of Robles Ranch contained 3 tiny embryos; one taken July 13, 1932, 5 miles north of Oracle contained 1 embryo, 26 mm. in length; and another taken July 14, 1932, 2½ miles north of Oracle contained 2 embryos, respectively 18 and 22 mm. in length.

Dipodomys merriami simiolus. Merriam kangaroo rat. An adult male was taken by Dice and Harris, March 24, 1930, about 5 miles east of Pitiquito, Sonora, on a broad flood-plain supporting an open growth of desert shrubs, mostly mesquite, palo verde, cholla cactus, and *Olneya*.

Five were trapped by Blossom in 1933 on the lower creosote-bush covered slopes at Papago Tanks, Pinacate Mountains. One was taken the same year in brittlebush (*Encelia*) habitat on the cinder slopes of Elegante Crater. Two very young individuals were caught April 24, 1933, in galleta grass about 10 miles north of Papago Tanks.

There is considerable variation in the color of specimens from the Pinacate Mountains, and some of the specimens are nearly as dark as *merriami* from Tucson.

A female taken April 24, 1933, by Blossom at Elegante Crater, Pinacate Mountains, contained two well-developed embryos. Two nursing females were taken April 25 at Papago Tanks.

Dipodomys ordii ordii. Ord kangaroo rat. One was secured by Dice in 1932, 6 miles southeast of Oracle, in catclaw–mesquite association, and another in sacaton association, along the San Pedro River at Hereford. Burt (1933, 119) reports it as common along the Santa Cruz River at Continental

and at Tumacacori Mission, and 1 specimen was taken in the Baboquivari Mountains. We have no record from the open desert plain.

Onychomys leucogaster ruidosæ. Grasshopper mouse. One was trapped by Dice in July 1932 at an elevation of 5000 feet at the mouth of Miller Canyon, Huachuca Mountains, in *Senecio* association; 2 were trapped in high sacaton grass along the San Pedro River at Hereford; and 6 in catclaw–mesquite association at the same place.

Onychomys torridus torridus. Scorpion mouse. In April 1930, 1 was trapped by Charles T. Vorhies and Dice in grass and mesquite association inside Vorhies' experimental plot on the Santa Rita Range Reserve, and 1 was trapped by Dice 5 miles northwest of Robles Ranch in modified mesquite forest association.

In 1931 Blossom took 4 at 4300 feet, near the mouth of Madera Canyon, Santa Rita Mountains, in grass and mesquite; 3 on the Santa Rita Range Reserve in *Isocoma* association; 1 in creosote bush association, 6 miles south of Tucson; 1 in cholla–mesquite–hackberry association, 10 miles south of Tucson; and 1 juvenile on the rocky slopes of Black Mountain, 10 miles south of Tucson.

In July 1932, Dice took 2 at 4400 feet elevation, 6 miles southeast of Oracle, in mesquite–grass association; and 1 at 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association.

Reported by Burt from cottonwood–willow association at both Continental and Tumacacori Mission.

In order to distinguish the two species of *Onychomys* we suggest that the common name "scorpion mouse" be limited to *Onychomys torridus* and its subspecies, and that the name "grasshopper mouse" be limited to the *Onychomys leucogaster* group.

Reithrodontomys megalotis megalotis. Desert harvest mouse. In July and August 1932, Dice took 1 at 3750 feet elevation, 5 miles north of Oracle, in palo verde–mesquite–grass association; 1 along the San Pedro River at Hereford, in catclaw–mesquite association; and 2 at 5000 feet near the mouth of Miller Canyon, Huachuca Mountains, in *Senecio* association. Two other very young harvest mice taken in *Senecio* association at the mouth of Miller Canyon but not preserved as specimens may have been either this species or *fulvescens*.

Reported by Burt from cottonwood–willow association at Continental.

Reithrodontomys fulvescens fulvescens. Sonoran harvest mouse. Two were taken by Dice in late July 1932 at the mouth of Miller Canyon in *Senecio* association.

Reported by Burt from cottonwood–willow association at both Continental and Tumacacori Mission.

A female taken July 28, 1932, near the mouth of Miller Canyon contained 6 small embryos.

Peromyscus crinitus disparilis Goldman. Canyon mouse. Blossom in 1932 trapped 2 on the light-colored granite rocks beside the tanks at Tinajas

Altas; 5 on the black lava of Raven Butte; 2 on the dark-colored rocks of the Wellton Hills; and 1 each from the pale-colored rocks of the northwestern edge of the Cabeza Prieta Range, from the black lava of the adjacent Crow Butte, and from the dark-colored rocks of Telegraph Pass in the Gila Mountains. In 1933 one was taken on the pale-colored rocks at Tule Tank. All these specimens are fairly uniform in pelage color, notwithstanding the considerable difference in the colors of the rocks on which they were taken, with the exception that the specimen from Tule Tank is more buffy on the upper parts than the others of the series.

The female taken May 5, 1933, at Tule Tank was nursing.

Peromyscus eremicus eremicus. Cactus mouse. In 1930 Harris and Dice trapped 6 on the western side of the Tortollita Mountains, 10 miles north of Rillito. In the same year Dice trapped 27 on Tumamoc Hill, near Tucson, and 4 on the lower Santa Catalina Mountains at the mouth of Pima Canyon, 10 miles north of Tucson. All these were taken on rocky slopes, covered with sahuaro, ocotillo, and palo verde, except that 1 from Tumamoc Hill was taken inside the Desert Laboratory building. Dice also took 2 near Robles Ranch, 25 miles west of Tucson, along steep sandy banks bordering sandy washes in modified mesquite forest association.

Blossom in 1930 and 1931 took 8 at Fort Lowell, 7 miles northeast of Tucson, in cottonwood–willow association; 7 on the northeastern slopes of the Tucson Mountains, 4 miles west of Tucson, in rock hill association; 7 on rocky ledges at the mouth of Pima Canyon; and 1 on rocky slopes at the mouth of Sabino Canyon, Santa Catalina Mountains. He trapped 1 in 1931 in Fresnal Canyon, Baboquivari Mountains. In 1932 he took 16 at Tinajas Altas, 19 on Raven Butte, and 1 in Telegraph Pass, Gila Mountains. In 1933 he took 3 in the Agua Dulce Mountains, 9 miles east of Papago Well, and 3 at Tule Tank. All these mice were taken on rocky slopes.

In 1932 Dice trapped 3 in Peppersauce Canyon, 8 miles southeast of Oracle, in a mesquite thicket on springy ground adjacent to the sycamore association occupying the bottom of the canyon; 14 on nearby rocky ground dominated by ocotillo; 4 about 6 miles southeast of Oracle in mesquite–grass association; 2 at an elevation of 4040 feet, $2\frac{1}{2}$ miles north of Oracle in a sandy wash bordered by oaks, mesquite, and sumac; and 2 at an elevation of 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association.

Some of the specimens from near Tucson and Oracle, excluding *pullus*, are close in general color tone to *eremicus* from farther west, but the series averages slightly darker than *eremicus* from the Colorado Desert. However, the differences are slight and we follow Burt (unpublished manuscript) in assigning these specimens to the subspecies *eremicus*. Burt shows that specimens from Hermosillo, which Blossom (1933a, 3–4) had assumed to represent *anthonyi*, are really referable to *eremicus*.

A female taken by Dice at the mouth of Pima Canyon, 10 miles north of Tucson, on April 12, 1930, contained 2 small embryos. A female taken January 23, 1931, by Blossom at Fort Lowell was nursing. Another taken

July 5, 1932, at Peppersauce Canyon, 8 miles southeast of Oracle, contained 2 embryos each 20 mm. long.

A king snake was seen by Dice to kill and swallow a cactus mouse at about 4 o'clock on the afternoon of April 17, 1930. When first seen by Mr. Kinney, of the Desert Laboratory staff, the snake was coiled about the mouse and was lying alongside the north wall of the stone chemistry building of the Desert Laboratory on Tumamoc Hill. A number of kinds of snakes occur in the rock hill habitat and these animals undoubtedly prey extensively on all the smaller rodents.

Peromyscus eremicus papagensis Goldman. Cactus mouse. Fifteen individuals of this dark-colored race were taken by Blossom in 1933 on the blackish lava at Papago Tanks, Pinacate Mountains, Sonora. There is considerable variation in the color of the series; however, breeding of these mice in the laboratory has shown the dark coloration to be inherited, and the very young individuals are much darker than the young of other, lighter-colored races of this species. In 1933 Blossom also took 3 mice of this subspecies on the Pinacate lava in Arizona, about 20 miles east of Tule Tank. All these were sent to the University of Michigan, where one pair produced a number of offspring, all of which are a rich dark buff in color.

A female taken by Blossom at Papago Tanks April 26, 1933, proved to be pregnant.

Peromyscus eremicus pullus. Cactus mouse. This dark-colored form was first discovered by Blossom (1933a, 3–4). It is known only from Black Mountain, an isolated lava hill rising from the desert plain 10 miles south of Tucson. Here in 1931 Blossom and William Turnage trapped 24 specimens on the rocky slopes, which are covered with sahuaro, ocotillo, and palo verde.

A female taken by Blossom on Black Mountain March 17, 1931, contained 3 embryos. Of two females taken at the same place on April 7, 1931, one was nursing and the other contained 3 embryos.

Peromyscus maniculatus rufinus. Deer mouse. Blossom found the deer mouse common in the upper parts of the Chíricahua Mountains in 1931 and trapped 6 in Rock Creek Canyon in yellow pine association with much grass as an under story, and 14 in Rustler Park, also in yellow pine association, but with much less grass covering the ground.

In the upper parts of the Santa Catalina Mountains the deer mouse is common, and in June 1932 Dice trapped 27 at elevations of 8000 to 8600 feet on the northern slopes of Mount Lemmon, in Douglas fir association. In streamside association, near by, 11 were taken. Near Summerhaven, at an altitude of about 7600 feet, 25 were taken on yellow pine slopes, but the species was much less numerous than in the Douglas fir forest at higher elevations.

Deer mice from the upper parts of the Santa Catalina and Chíricahua Mountains are dark in color and must for this reason be assigned to the subspecies *rufinus*. However, the specimens at hand from the upper Santa Catalinas are much darker and less buffy than those from Rustler Park and

Rock Creek Canyon in the Chíricahuas. Of the mice taken in the Santa Catalina Mountains, those from an elevation of about 8500 feet on the upper northern slopes of Mount Lemmon are darkest in color, while those taken at an elevation of about 7500 feet near Summerhaven are somewhat lighter in color.

A female taken alive June 7, 1932, near Summerhaven had 3 young born in the trap. Two females taken June 19, 1932, on the northern slope of Mount Lemmon had each 5 embryos, one set being very small, those of the other set having each a length of 13 mm. Of 2 females taken here on June 20, one contained 4 small embryos, the other 3 embryos each 11 mm. long.

Peromyscus maniculatus sonoriensis. Deer mouse. No deer mice were secured in the encinal belt on the northern slope of the Santa Catalina Mountains, but one was taken by Dice in July 1932 in Pima County, 10 miles southeast of Oracle, at the upper edge of the grassland belt, on a "mesa" at an elevation of 4600 feet, in mesquite–grass association. A pair were taken $2\frac{1}{2}$ miles north of Oracle at the edge of a sandy wash, in a growth of oaks, catclaw, and three-leaved sumac. Another individual was taken at an altitude of 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association, at the lower edge of the grassland belt.

At the eastern base of the Huachuca Mountains Dice trapped 1 in July 1932, in an open stand of oaks on the alluvial fan at the mouth of Miller Canyon, and another near the stream, where a few sycamores and walnuts grew among the oaks. At the same place 13 were trapped in *Senecio* association. At this locality the brush mouse (*Peromyscus boylii*) was numerous among the oaks, but only 1 brush mouse was secured in *Senecio* association, so there is here a distinct habitat difference between the deer mouse and the brush mouse.

The species is rare on the grassland belt on the northern slope of the Santa Catalina Mountains, and the mice from this belt taken near Oracle are much paler than those from the higher mountains and must be assigned to the subspecies *sonoriensis*. Specimens from the lower edge of the Huachuca Mountains at the mouth of Miller Canyon are not quite so pale buffy as those from near Oracle.

Burt reports it not common in cottonwood–willow association along the Santa Cruz River at Continental.

Peromyscus leucopus arizonæ. White-footed mouse. Along the San Pedro River at Hereford 12 were trapped by Dice on August 2, 1932, in sacaton association, and 4 in catclaw–mesquite association.

Burt reports it from cottonwood–willow association at Continental.

Peromyscus boylii rowleyi. Brush mouse. Blossom in 1931 took 3 at about 5300 feet elevation in Madera Canyon, Santa Rita Mountains, in oak association.

In the Santa Catalina Mountains Dice in 1932 found it to range over the montane belt and down to the lower edge of the encinal belt. On the northern slope of Mount Lemmon 1 was taken in Douglas fir association at 8550 feet

elevation, the highest station at which trapping was done, and 2 in brush along a small stream. Near Summerhaven 31 were taken in yellow pine association. At the lower control station on the automobile road, at about 5600 feet, 2 were taken in oak association. In Peppersauce Canyon, 8 miles southeast of Oracle, at 4600 feet elevation, 4 were taken in sycamore association, and 3 in nearby oak association. This was the lowest station at which the species was found. At the mouth of Miller Canyon, Huachuca Mountains, at an elevation of about 5100 feet, Dice found the species common on the oak-covered plain at the base of the mountains, where 18 were taken; on the oak-covered rocky slopes, where 15 were taken; and in sycamore association, where 11 were taken. A single individual was taken in the immediately adjacent *Senecio* association, in a fenced field where the shrubs were quite old and high.

Burt reports it from cottonwood–willow association at Tumacacori Mission.

In the upper parts of the Santa Catalina Mountains the brush mouse is much less abundant than the deer mouse, but in the encinal belt the brush mouse is the more numerous of the two species.

The brush mouse is semi-arboreal in habit. When surplus individuals were released in camp they always ran to the nearest tree, up which they then climbed. These mice also pass from tree to tree by following interlacing branches. Dice has seen them take refuge in hollow trees, entering through a hole in a dead stub or other opening.

These mice occur frequently around large boulders, beneath which they doubtless find homes. In yellow pine forest near Summerhaven they were taken beside logs and around the bases of trees. In the oak forests they are frequently trapped at the bases of oak trees and under bushes. The abundance of the species in the encinal belt is probably due in part to the numerous home sites available in the cavities of the oak trees.

In the Huachuca Mountains at the mouth of Miller Canyon Dice in July 1932 found many little piles of acorns around the bases of the oak trees and in cavities in hollow limbs, each acorn having been opened by a hole gnawed in its side. This must have been the work of these mice, for chipmunks are not known from these mountains. The acorns were old and dried and probably were remnants from the crop of the previous summer, for the oaks had grown very few acorns in the summer of 1932. The shortage of acorns this year was undoubtedly due to a plague of caterpillars which early in the season stripped most of the young leaves from the oak trees. The leaves grew out again after the caterpillars had gone, but acorns did not develop.

An adult female taken July 4, 1932, in Peppersauce Canyon had milk in the mammæ, but there were no embryos. An adult female taken July 14, 1932, at the mouth of Miller Canyon contained 4 embryos, of which the size was not recorded. Two adult females taken at this place July 21 both had milk in their mammæ, and both showed evidence of recent parturition. Another female taken July 22 contained 4 embryos, each about 13 mm. in

length. On July 23 two young mice, both in juvenile coat, were taken together here in the same Sherman trap, indicating that these were two young from one family traveling together.

Peromyscus truei truei. Pinyon mouse. One was taken by Blossom in 1931 at 7800 feet elevation in yellow pine forest with a grass under story, in Rock Creek Canyon, Chíricahua Mountains.

Sigmodon hispidus cienegæ. Cotton rat. Blossom took 1 in 1932 on a small grassy slope near the Desert Laboratory, in rock hill association on Tumamoc Hill, near Tucson. Two were trapped by Dice August 2, 1932, in catclaw–mesquite association, with some clumps of large grass, along the San Pedro River at Hereford. Burt reports it from cottonwood–willow association at Continental.

Three were taken by Dice in July and August 1932 at the mouth of Miller Canyon, Huachuca Mountains, along a broken-down rock fence in an enclosure partially protected against grazing. At this place there was a considerable amount of grass under an open stand of oaks. The situation is assigned to the sycamore association, although it was perhaps 100 yards from the banks of the arroyo where the nearest sycamores were growing.

Sigmodon minimus minimus. Cotton rat. Four were taken by Dice August 3, 1932, at an elevation of 4300 feet, 4 miles west of Hereford, in grass and mesquite association. Their runways were common in the grass at this station. Most of those taken were immature.

With better material available for comparison it is evident that the 2 young cotton rats taken in 1927 in the Tularosa Basin, New Mexico, and assigned to the species *minimus* (Dice, 1930, 26) really are immature *hispidus*, and belong to the form *Sigmodon hispidus berlandieri*.

Neotoma albigula albigula. White-throated wood rat. The wood rat is common in the vicinity of Tucson on rocky slopes; it is less numerous on the adjacent upper bahadas, and on the lower desert plain it is rare. Of the three common rock-inhabiting rodents of the Sonoran desert near Tucson, the white-throated wood rat is much less restricted to rock habitats than either the rock pocket mouse or the cactus mouse.

Harris took 2 in March 1930 on the western border of the Tortollita Mountains, one on a rocky ledge and the other on the upper bahada. At this place occupied wood-rat houses were numerous on the rock ledges. He and Dice took 4 in the attic of the Desert Laboratory at Tucson. Three were trapped by Dice in April 1930 in grass and mesquite on the Santa Rita Range Reserve, where their houses were numerous. Several houses were noted on the rocks of the mountain slopes at the mouth of Pima Canyon, 10 miles north of Tucson, and 1 was trapped in upper bahada association 9 miles north of Tucson. Houses were fairly numerous on the upper bahada at this place, but lower down, about 8 miles north of Tucson, in palo verde–brittlebush association, only a few houses were seen.

In late 1930 and early 1931 Blossom took 1 at 5200 feet elevation in Madera Canyon, Santa Rita Mountains, in oak association; 1 at 4300 feet on the

Santa Rita Range Reserve in grass and mesquite; 1 near Fort Lowell, 7 miles northeast of Tucson, in cottonwood–willow association; 2 in cholla–mesquite–hackberry association near Black Mountain, 10 miles south of Tucson; 4 on the rocky slopes of Black Mountain; and 5 on the rocky northeastern slopes of the Tucson Mountains.

This species was found by Dice to be common in the grassland belt on the northern slope of the Santa Catalina Mountains, but none were taken in the montane belt, where it is replaced by *Neotoma mexicana*. In July 1932, 2 were trapped 3 miles southeast of Oracle, at the lower edge of the encinal belt, near large boulders in open oak association with considerable "bear grass" (*Nolina*). Four were trapped on a "mesa" at the northern edge of Pima County, 10 miles southeast of Oracle, in grass and mesquite. Nests were common and 13 wood rats were trapped in mesquite–grass association 6 miles southeast of Oracle. At this place the soil is sandy and there are few large rocks on the surface of the ground. Nests were numerous and 1 wood rat was taken near Peppersauce Canyon, 8 miles southeast of Oracle, in clumps of *Opuntia* cactus and around rocks in ocotillo association. Wood-rat houses also were numerous and 4 animals were trapped at an altitude of 3750 feet, 5 miles north of Oracle, in palo verde–mesquite–grass association.

In early August 1932 Dice took 3 in catclaw–mesquite association near the San Pedro River at Hereford. Three others were taken near rock exposures on oak-covered slopes at the mouth of Miller Canyon, at the eastern base of the Huachuca Mountains.

Two of the 4 specimens trapped on Black Mountain are very dark in color. Their color is darker and richer in red than that of specimens of the subspecies *sheldoni* from the Pinacate Mountains of Sonora. On the desert plain near the base of Black Mountain 2 wood rats were secured, both of which are normally pale in color.

The mammæ in this species are 2 pairs in the inguinal region. A female taken by Dice March 18, 1930, on Tumamoc Hill, Tucson, contained 1 embryo 18 mm. long, and another female taken at the same place on March 20 contained 2 small embryos. A female taken by Blossom December 16, 1930, in the Tucson Mountains showed evidence of nursing. Another female taken April 8, 1931, at the foot of Black Mountain was nursing 2 young, which were about two weeks old, and she contained 3 embryos of a second litter. A female taken by Blossom May 6, 1933, on the Pinacate lava in southwestern Arizona was nursing. A female taken July 7, 1932, 3 miles southeast of Oracle contained 1 embryo about 15 mm. in length.

A female taken December 13, 1930, and a male taken December 14, in the Tucson Mountains, each had a botfly larva in the skin of the throat.

The lens of the eye in this wood rat is clear and without color, in correspondence with its nocturnal habit.

Neotoma albigula mearnsi. White-throated wood rat. Two were taken by Blossom in 1932 on rocky slopes at Tinajas Altas and 1 on Raven Butte. These specimens are typical of this pale-colored race. In 1933 Blossom took

1 near the base of the Agua Dulce Mountains in creosote bush association and 1 among the rocks of the Pinacate lava in southwestern Arizona, 20 miles east of Tule Tanks. The 2 last-mentioned specimens are darker than typical *mearnsi* and approach *albigula* in color.

A female taken October 8, 1932, on Raven Butte was evidently nursing.

Neotoma albigula sheldoni. White-throated wood rat. This is a dark-colored race known only from the Pinacate lava in Sonora. Four were taken by Blossom in 1933 at Papago Tanks, and 1 on the Pinacate lava near Elegante Crater. There is some variability in color among these specimens, but they are decidedly darker than typical *albigula*.

A female taken April 24, 1933, near Elegante Crater was evidently nursing. Two females taken April 26, 1933, at Papago Tanks each contained 2 embryos.

Neotoma mexicana mexicana. Mexican wood rat. Blossom trapped 3 in 1931 under the Boy Scout Camp building in Rustler Park, Chíricahua Mountains.

Neotoma mexicana bullata. Mexican wood rat. In June 1932 Dice found this species numerous in the montane belt on the upper Santa Catalina Mountains. Five were trapped near large boulders on yellow-pine covered slopes near Summerhaven, and their nests were numerous around these boulders. One was seen in oak brush at this place. One was trapped in a brushy thicket along a mountain brook at about 8500 feet elevation on the northern slope of Mount Lemmon, and another was taken in Douglas fir association at the same elevation. The forest rangers stated that wood rats occur in the lookout station on the top of Mount Lemmon.

Neotoma lepida auripila Blossom. Cactus wood rat. Blossom secured 5 in 1932 and 1933 in the Agua Dulce Mountains, 9 miles east of Papago Well, Pima County, Arizona, and took another on Crow Butte, 9 miles east of Tinajas Altas.

Blossom (1933b, 3–4) has already called attention to the striking correlation between this pinkish buff woodrat and the reddish-colored rocks of the Agua Dulce Mountains.

A female taken October 16, 1932, on Crow Butte was evidently suckling.

Neotoma lepida bensoni Blossom. Cactus wood rat. This blackish race of the *lepida* group occurs, so far as is known, only on the Pinacate lava in Sonora (Blossom, 1935, 2–3). Two were taken on rocky slopes at Papago Tanks, and 1 on the Pinacate lava near Elegante Crater.

Mus musculus musculus. House mouse. One was taken by Blossom in 1931 in cottonwood–willow association near Fort Lowell, 7 miles northeast of Tucson.

Erethizon epixanthum couesi. Porcupine. Mrs. J. G. Stevens, a resident in Pinery Canyon, Chíricahua Mountains, stated in 1931 that 2 porcupines had been killed in these mountains during the 27 years that she had lived there. She believed them now to be extinct in these mountains, for it has been many years since she has seen or heard of one.

Lepus alleni alleni. Antelope jack rabbit. In 1930, 10 or more were seen

by Dice and 5 shot on the Santa Rita Range Reserve, in grass–mesquite association. One was seen by Harris and Dice in mesquite and grass about 5 miles south of Robles Ranch, or about 30 miles southwest of Tucson. It was numerous in 1930 in Sonora over the whole route from Sasabe to Libertad, with no apparent break in range at any place. It is seemingly most common in areas with a good growth of grass under moderately high but open desert shrubs, but it occurs also in desert habitats having little grass. Specimens were taken by Dice and Harris in Sonora at Verrugo Pass, 50 miles northeast of Libertad; at Picu Pass, 20 miles east of Libertad; and at a point 22 miles north of Altar.

In 1930 Blossom shot 1 in upper bahada association near the mouth of Bear Canyon, not far from the southern base of the Santa Catalina Mountains. In 1931 Blossom observed it in the following localities: Santa Rita Range Reserve at elevations of 3300 to 4300 feet, in grass–mesquite association; 25 miles south of Tucson in *Isocoma* association; 10 to 16 miles south of Tucson in cholla–mesquite–hackberry association; just south of Tucson in creosote bush association; 2 miles west of Tucson in creosote bush association; 5 miles north of Tucson in creosote bush association; and near the southern base of the Santa Catalina Mountains in both creosote bush and upper bahada associations.

In 1932, 1 was seen by Dice in scattering oaks 5 miles southeast of Oracle, and 3 others in mesquite–grass association 6 miles southeast of Oracle.

Vorhies and Taylor (1933, 480) state that this species seems "to prefer grassy slopes at moderate elevations. The animals seem to like the bahadas or mesas above the giant cactus belt, where grasses, mesquites, and catclaws abound. They occur also, somewhat scattered, on the creosote desert, and even, at times, in the heavy mesquite growth along the valley bottoms. . . . *Lepus alleni* is rarely observed in broken or hilly country."

A female taken by Dice April 1, 1930, on the Santa Rita Range Reserve contained 2 embryos of a length of 85 mm.

An adult male taken by Dice at Verrugo Pass, 50 miles northeast of Libertad, Sonora, on March 25, 1930, had 3 large botfly larvæ in the skin of the throat.

Lepus californicus eremicus. Black-tailed jack rabbit. Occurs all over the desert region, ranging upward to the lower edge of the encinal belts on the mountains.

In 1930, Dice saw 5 on the Santa Rita Range Reserve in grass–mesquite association; 6 near Tucson in creosote bush association; 4 near Robles Ranch, 25 miles west of Tucson, in the same type of habitat; 1 in palo verde–brittlebush association 8 miles north of Tucson; and 2 near the base of the Santa Catalina Mountains, 9 miles north of Tucson, in upper bahada association.

Blossom in 1930 and 1931 observed it in the following localities: on the Santa Rita Range Reserve in grass–mesquite association; just south of Tucson in creosote bush association; 10 to 16 miles south of Tucson in cholla–mesquite–hackberry association; near the Tucson Mountains in creosote bush associa-

tion; 5 miles north of Tucson in creosote bush association; and near the south base of the Santa Catalina Mountains in both creosote bush and upper bahada associations.

In 1932 Dice found it numerous on the grassland belt north of the Santa Catalina Mountains and recorded 7 from mesquite–grass association 6 miles southeast of Oracle; 1 from mesquite–grass association on a "mesa" 10 miles southeast of Oracle; and 2 at Peppersauce Canyon 8 miles southeast of Oracle, on rocky outcrops dominated by ocotillo. One of these last-mentioned animals, when disturbed, ran into the lower edge of the adjacent oak forest. This was at an elevation of 4700 feet, the highest elevation at which the species was noted.

Vorhies and Taylor (1933, 480) state that "on the grassy bahadas at altitudes of perhaps 3,500 feet, the antelope jack rabbits are usually several times as numerous as the *Lepus californicus* type; but in the mesquites along the valley bottoms, and on the barren creosote bush desert, the *L. californicus* type is usually more numerous."

Reported by Burt from cut-over mesquite forest association at Continental.

The jack rabbits are most active at night, but they begin to move about and feed in the late afternoon. An adult female which was shot by Dice on the Desert Laboratory grounds, Tucson, at about 5:30 p.m. on March 18, 1930, had in her mouth a leaf stem of *Parosela parryi* and a small bud shoot of *Plantago ignata*. The plant identifications were kindly made by Forrest Shreve.

The female above mentioned contained 3 embryos, 120 to 140 mm. in length and nearly at term. Accompanying the female was an adult male with well-developed testes. This might indicate a more or less permanent pairing of the sexes during the breeding season. However, if the female jack rabbit, like the female domestic rabbit, will accept the male immediately after parturition, this observed association of the male and female might indicate nothing more than a temporary association to be followed by mating after the impending birth of the litter.

A male taken by Dice March 20, 1930, on the Santa Rita Range Reserve had well-developed testes, and a female taken at the same time and place contained no embryos, but the mammæ were filled with milk. Another female taken on the Santa Rita Range Reserve on April 1 contained 3 small embryos, and there was a slight amount of milk in the mammæ.

A very large red-tailed hawk was observed feeding on the carcass of a black-tailed jack rabbit March 20, 1930, on the Santa Rita Range Reserve, about 30 miles south of Tucson. The hawk rose as Dice and Vorhies approached, and its identification was certain. The head of the jack rabbit and most of the fore part of the body had been eaten. It is possible that the jack rabbit had been killed by some other animal, for it seems unlikely that the hawk could have consumed about one-third of this large animal at one meal.

These hares are much parasitized, ticks and fleas being common external parasites. The ticks are found especially around the ears. The adult female

taken March 18, 1930, on Tumamoc Hill contained many tapeworm cysticerci and had a botfly larva on her rump. The male taken at the same time had also many cysticerci and had 6 or more large botfly larvæ on his rump. Another male taken March 20 on the Santa Rita Range Reserve also had a botfly larva on his rump. An adult female taken at the same time and place had a large tapeworm cyst on her thigh.

Sylvilagus floridanus holzneri. Huachuca cottontail. Several large gray cottontails were seen by Dice in July and August 1932 on the lower oak-covered rocky slopes of the Huachuca Mountains at the mouth of Miller Canyon. These rabbits differed so much in appearance and behavior from *arizonæ*, which is common at this lower elevation, that it seems certain that they were *holzneri*, though unfortunately no specimens were secured. The residents distinguish the large mountain cottontail from the smaller form found on the lower plains. *Holzneri* was originally described from the Douglas spruce zone near the summit of the Huachuca Mountains.

Sylvilagus audubonii arizonæ. Arizona cottontail. In 1930 Harris secured flashlight records of 2 in a sandy wash on the western side of the Tortollita Mountains, 10 miles north of Rillito; 2 were shot by Harris and Dice on the desert plain a few miles southwest of Tucson in creosote bush with some mesquite; tracks were seen in a sandy wash 8 miles north of Tucson; 1 was seen in palo verde–brittlebush association near the same place; 1 was seen 9 miles north of Tucson in upper bahada association; 2 were noted on the rocky slopes of Tumamoc Hill near the Desert Laboratory; and 1 was living under a pile of boards at the shop of the Desert Laboratory at the foot of Tumamoc Hill, where the surrounding vegetation was largely creosote bush.

At Verrugo Pass, 50 miles northeast of Libertad, Sonora, Dice took 2 breeding males on March 25, 1930.

Blossom in January and February 1931 shot 3 on the Santa Rita Range Reserve at an elevation of about 3800 feet, in grass–mesquite association, and numbers of others were observed in this association. In the vicinity of Tucson he found this species numerous in the mesquites along the washes and in both creosote bush and upper bahada associations.

Burt reports it from mesquite forest association at Continental.

In 1932 this cottontail was found by Dice to be numerous in the scattering oaks of the lower encinal near Oracle. Two were seen in the heavier oaks on the slopes south of Peppersauce Canyon, 8 miles southeast of Oracle, and 1 in the sycamore association of the canyon bottom. Three were seen on rocky slopes in ocotillo association, just north of Peppersauce Canyon; this was at an elevation of 4700 feet, the highest point at which the species was noted. In mesquite–grass association 6 miles southeast of Oracle it was numerous. One was seen among mesquite and oak in a sandy wash $2\frac{1}{2}$ miles north of Oracle. Three were seen in sacaton association beside the San Pedro River at Hereford. One, believed to be of this species, was seen among the lower oaks on a rocky ridge at the mouth of Miller Canyon, Huachuca Mountains, at an elevation of 5200 feet. At this point its range overlaps slightly

that of the mountain cottontail (*Sylvilagus floridanus holzneri*), and both occur in the same habitat.

On March 30, 1930, Dice saw several young near the Desert Laboratory building on Tumamoc Hill near Tucson. These young cottontails were estimated to be about 5 weeks old.

An adult female taken by Harris and Dice 10 miles southwest of Tucson on March 18, 1930, contained no embryos, but the mammæ were filled with milk. Another female taken at the same time and place contained 4 embryos, varying in length from 40 to 50 mm., and her mammæ also were filled with milk.

Sylvilagus species. Cottontail. Percy Leaverton, forest ranger, states that a large mountain cottontail occurs rarely in the upper part of the Santa Catalina Mountains, where he has seen it in the yellow pine forest, but chiefly around patches of scrub oak. Mr. O'Neil, the storekeeper at Summerhaven, also states that several years previous to 1932 a large cottontail was seen a number of times around his cabin near Summerhaven.

No specimens of cottontails from the upper Santa Catalina Mountains are known to be in existence, and the species therefore cannot be determined. It may be either *Sylvilagus nuttalli pinetis*, which occurs on the White Mountains to the northeast, or *S. floridanus holzneri*, which occurs on the Huachuca Mountains to the southeast.

Pecari angulatus sonoriensis. Peccary, javelina. In March 1930 Harris and Dice found numerous signs on rocky slopes along the western canyons of the Tortollita Mountains, about 10 miles north of Rillito. Doutt (1934, 269) secured one in Bear Canyon in these mountains. Blossom, in April 1933, saw 2 in Pima County, Arizona, in a thick growth of sahuaro and cholla cactus, 13 miles north of Sonoyta, Sonora.

Odocoileus hemionus subspecies. Mule deer. A male was observed by Blossom in 1931 at about 3000 feet elevation in *Isocoma* association on the Santa Rita Range Reserve. On February 25, 1931, a female was seen by Blossom near the automobile road at 5500 feet in oak association on the northern slope of the Santa Catalina Mountains.

D. T. MacDougal stated in 1930 that a few still occurred in the Tucson region on the upper bahada and on other parts of the desert plains. At his home 9 miles north of Tucson the mule deer and two species of white-tailed deer occur, their ranges overlapping on the upper bahada at this place.

Mr. Daley, an old-timer living near Oracle, reports that mule deer were formerly common along the San Pedro River (desert life belt). Dice saw 3 on July 14, 1932, in grass and low brush in the grassland belt, 3 miles north of Oracle.

Odocoileus couesi. Coues deer. Reported by D. T. MacDougal in 1930 to occur in numbers on the lower rocky slopes of the Santa Catalina Mountains near Pima Canyon and to feed down a short distance over the upper bahada. Dice on several occasions in April 1930 saw an individual, perhaps the same one, on the rocky mountain slopes near Pima Canyon. Droppings, probably mostly made by this species, were numerous at this time over a

small hill on the upper bahada located about ½ mile from the base of the mountains.

A shed antler was picked up by Dice in March 1930 in Picu Pass, about 20 miles east of Libertad, Sonora.

One skull and one antler were picked up by Blossom in 1931 in Rock Creek Canyon in the Chíricahua Mountains. Many deer were observed at elevations of 7000 to 8600 feet in these mountains.

Percy Leaverton, forest ranger, reports this deer to be common in the upper Santa Catalina Mountains, part of which is a game refuge. Three were seen by Dice in June 1932 in Douglas fir forest on the northern slopes of Mount Lemmon at an elevation of about 8500 feet, and signs were noted in yellow pine forest at about the same elevation. A skeleton was found in the pine forest near Summerhaven and the lower jaws were saved for identification. Droppings were common at this time in yellow pines and in the patches of oak brush at about 7700 feet elevation.

Signs were common in July 1932 and 2 deer were seen by Dice on the oak-covered lower slopes of the Huachuca Mountains at the mouth of Miller Canyon.

Odocoileus (virginianus?) subspecies. White-tailed deer. D. T. MacDougal stated in 1930 that a large white-tailed deer occurs sparsely on the rocky slopes of the southern Santa Catalina Mountains near the mouth of Pima Canyon and elsewhere, and feeds out on to the upper bahada for a mile or more. Mr. Daley, an old-timer, stated in 1932 that two species of white-tailed deer formerly occurred on the grassland to the north of the Santa Catalinas.

Antilocapra americana subspecies. Pronghorn. Tracks were seen by Blossom in 1933 on the desert about 35 miles west of Sonoyta, Sonora, near Elegante Crater.

Ovis canadensis gaillardi. Bighorn. The type of this subspecies was collected by E. A. Mearns (1907, 240) in the Tinajas Altas Mountains (then considered part of the Gila Range), between Tinajas Altas and the Mexican boundary.

Blossom saw signs at Tinajas Altas and at Tule Tank in 1932 and 1933, and at Papago Tanks in 1933. Sykes (1927, 69) took a photograph of bighorns at Tinajas Altas in 1925.

Ovis canadensis mexicanus. Bighorn. Reported by Mearns (1907, 239) to occur in 1885 in the Santa Rita and Santa Catalina Mountains. D. T. MacDougal in 1930 stated that a few still occurred on the lower rocky slopes of the Santa Catalina Mountains, near the mouth of Pima Canyon and elsewhere. He says that although they occasionally cross the desert plains from mountain range to mountain range, they are most at home on the rocky slopes.

Ovis sheldoni. Bighorn sheep. This dwarf form was described by Merriam (1916, 129–132) from the Sierra del Rosario, northern Sonora. This sierra is a low isolated ridge lying about 12 miles southwest of the Tinajas

Altas Mountains. Charles Sheldon, who secured the type specimen in 1916, thought that the total bighorn population on the Sierra del Rosario was "certainly less than ten."

ECOLOGIC COMMUNITIES OF SOUTHEASTERN ARIZONA

Southwestern Arizona is covered by desert and is a part of the Sonoran biotic province (Dice, unpublished manuscript). Southeastern Arizona, on the contrary, is covered by high plains from which rise a number of isolated mountain masses. The ecological relationships of southeastern Arizona are rather uncertain, and in this report we tentatively assign the area to the Chihuahuan biotic province (fig. 4).

A *biotic province* (see Dice, 1931, 317) is a major division of a continent, distinguished by its dominant types of ecologic communities. In general a biotic province is also distinguished by its ecologic climaxes, its fauna and flora, its climate, its physiography, and its soils. Each of the biotic provinces in the area under discussion is divided into two or more biotic districts. *Biotic districts* are distinguished by the same features as are biotic provinces, but the differences are not so great.

Adjacent biotic provinces and districts merge more or less gradually into one another, and in nature no hard and fast line distinguishes them. On our map it has been necessary to separate the several biotic divisions by lines, but we hope that no one will thereby be deceived into thinking that a sudden change in ecologic conditions necessarily occurs at any place marked as a biotic boundary.

A very pronounced feature of the biogeography of southern Arizona is the occurrence of strongly marked life *belts*, which are obviously related to climate, which in turn is related in part to altitude. The life belts therefore are more or less closely correlated with altitude. On the Santa Catalina Mountains, for instance, a belt of pines, with some firs and spruces, occupies the higher part of the mountain mass. Below this is a belt of encinal, characterized by oaks and junipers. Still lower the oaks drop out and grass and mesquite dominate the vegetation. On the lowest slopes of these mountains desert vegetation occurs. According to the plan adopted in this report, a belt is considered to be a subdivision of a biotic district. Although somewhat similar belts recur in adjacent biotic districts and adjacent provinces, we consider that a life belt is usually relatively uniform only within the limits of a single biotic district.

In the list of mammals given for each ecologic association we have recorded for each species the number of individuals taken or seen and positively identified in that association. For those species of which no individuals were taken or seen, we state the evidence for the record. For the more common species it has been impossible to keep an accurate count of the number of individuals seen in each association, and for these species we give only a statement of their comparative abundance.

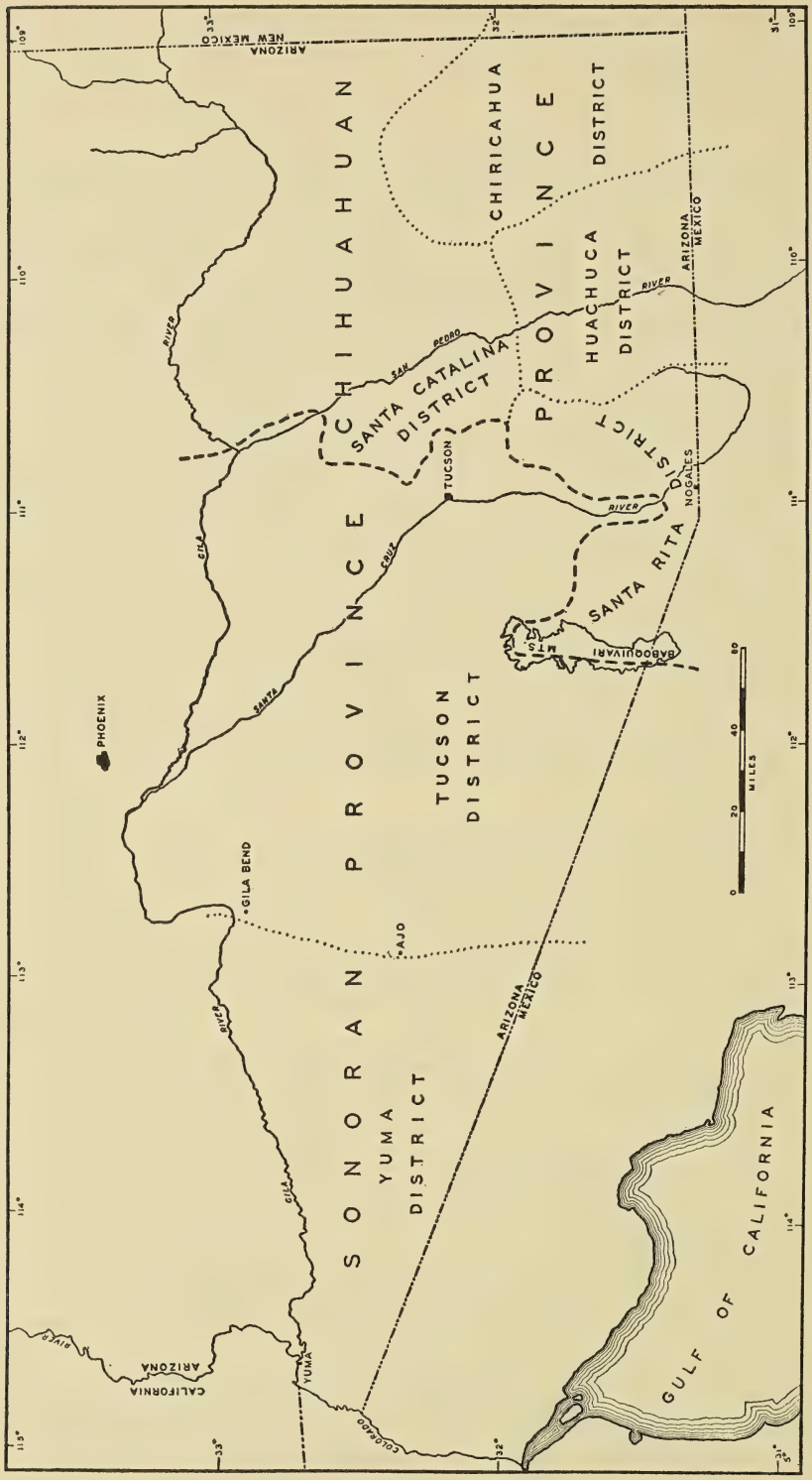

FIG. 4—Map of southern Arizona, showing biotic provinces and biotic districts as determined by this study.

The upper and lower altitudinal limits of life belts and ecologic communities vary greatly with latitude, with slope exposure, with height of the locality above general base level, with the stage of ecologic succession, and with other factors. It is therefore difficult to state the altitudinal limits of the several life belts. Where altitudinal limits of certain communities or life belts are given in this paper, reference is made only to the particular locality described.

Each life belt and each biotic district is considered to be composed of several ecological associations. An *association*, as the term is used by us, includes all the plants and animals occurring together in a relatively stable environment. We have made no attempt to designate the sequence of the communities in ecologic succession and therefore we have not employed the terminology of Clements. We consider an association to be limited to one biotic district and to one life belt, but similar associations often occur in adjacent districts and in adjacent belts.

Our study of ecologic communities is most complete in the vicinity of Tucson and on the north slope of the Santa Catalina Mountains, but the field work has been hurried, and the classification given is tentative. The descriptions of communities from the upper San Pedro Valley and the eastern slope of the Huachuca Mountains apply only to the particular stations studied, and should not be assumed to constitute a general classification for the Chihuahuan province. Our field work in southwestern Arizona and northwestern Sonora was directed chiefly toward securing rock-inhabiting rodents, and no attempt is here made to describe the ecologic communities of the Yuma district, although the communities there are known to resemble somewhat the communities of the Tucson district.

CHIHUAHUAN BIOTIC PROVINCE

The Chihuahuan (pronounced chi-wáh-wahn) biotic province as here defined includes not only the Chihuahuan desert as mapped by Shreve (1936, 197), but also the surrounding and interspersed areas of mesquite grass (desert grassland) mapped by Shantz and Zon (1924, fig. 2). The province is believed to be most extensively developed in the state of Chihuahua, but we have little published information about the ecology of Mexico.

The vegetation of the plateau of southeastern Arizona and southwestern New Mexico is dominated by arid grasses, with which commonly are associated an open stand of mesquite and other shrubs. From this plateau rise a number of mountains, on which are altitudinal belts of encinal and of coniferous forest.

Southeastern Arizona is placed by Fenneman (1930) in the Basin and Range Physiographic Province, along with the Sonoran desert. However, its vegetation and mammalian fauna are quite different from those of the Sonoran desert.

The Chihuahuan province in southeastern Arizona corresponds in part to the Elevated Central Tract of Mearns (1907, 74, and pl. 2) and to the Eastern Plains Area of Swarth (1929, 270–272), but we do not hold to the

boundaries mapped by either Mearns or Swarth. It corresponds in part to the *Aristida–Bouteloua* association of Clements (1920, 144–149), but we include the forest belts on the mountains, which Clements would place in other formations.

We cannot from the information at hand draw precise boundaries between the Santa Catalina, Santa Rita, Huachuca, and Chíricahua biotic districts. The Patagonia Mountains clearly belong to the Santa Rita district, but we have no information concerning the fauna of the Mule Mountains, Whetstone Mountains, or Dragoon Mountains, and therefore the boundary lines between the several districts must for a time remain uncertain. These four biotic districts are rather minor divisions of the Chihuahuan province, and some of them perhaps should be grouped together to form a single district.

The mammalian faunas of these four mountain areas differ from one another, both in species and in subspecies. For instance, the cliff chipmunk (*Eutamias dorsalis*) is seemingly absent from both the Huachuca and Santa Rita Mountains, while it is common in the Santa Catalinas from the summits down to the lower edge of the encinal belt, and it also occurs in the Chíricahua Mountains. Also each biotic district has different species and subspecies of pocket gophers. However, our information is inadequate at this time for a satisfactory comparison of the mammalian faunas of the four districts.

Santa Catalina Biotic District

Four life belts may be distinguished on the slopes of the Santa Catalina Mountains: montane forest, encinal, arid grassland, and desert. The desert belt is less well developed on the northern side, where our study was conducted, than on the southern side of these mountains. On the other hand, the southern slopes are steeper than the northern and are more exposed to the influences of sun and wind. The upper life belts, therefore, are best developed, though perhaps not so sharply marked, on the northern slopes.

Shreve's (1915) study of the vegetation of the Santa Catalina Mountains was made mostly on the southern slope, while our study has been carried on mostly on the northern side. Our conclusions and classification therefore differ from Shreve's to some extent, though we are in general agreement with him, and we have based our classification to a large extent on his excellent descriptions of the plant communities.

Montane Belt (Santa Catalina District)

The higher elevations of the Santa Catalina Mountains are covered by conifer forests. By far the larger part of this forest is of the yellow pine type, here growing usually on very steep slopes. On some north-facing slopes of the uppermost canyons and gulches the Douglas fir association replaces yellow pine, and this community is best developed on the high northern slopes of Mount Lemmon. However, yellow pine occupies the summit of Mount Lemmon, as well as all of the higher southern slopes of the mountains. It is impossible, therefore, to consider that the Douglas

fir forest constitutes a distinct life belt on these mountains. If the Santa Catalina Mountains were higher in elevation it would be expected that Douglas fir and other conifers characteristic of higher altitudes would form a continuous belt around the summits. The actual conditions on these mountains, however, seem best described by considering the Douglas fir forest to be a distinct ecologic association of the montane life belt.

In the bottoms of some of the canyons, such as Sabino Canyon, which contain permanent streams, there is a slightly heavier growth of vegetation than on the adjacent yellow pine slopes, but this community is but slightly distinguished from the adjacent communities. Grassy meadows seem to be practically absent from these mountains. Outcrops of rock cliff and rock boulder fields occur in places on the higher mountains, especially on the southern side, and such rock exposures are more abundant on the south face of the lower parts of the mountains. On exposed south slopes in the montane belt there are also a number of patches, some fairly extensive, of oak brush.

The mammalian fauna of the montane belt is rather small as compared with the fauna of the nearby desert, or with the fauna of the corresponding belt in the mountains of Colorado. The area in the Santa Catalina Mountains covered by montane forests is actually not very great, and the scantiness of the mammalian fauna is probably correlated both with the small area and with the general aridity of the available habitats.

Douglas fir association (Santa Catalina district)

"The Fir Forest," in Shreve, *The Vegetation of a Desert Mountain Range as Conditioned by Climate Factors*, Carnegie Inst. Wash. Pub. No. 217, 33–35, 1915.

Mammals	Records
Eutamias dorsalis dorsalis, cliff chipmunk	5
Sciurus arizonensis catalinæ, Arizona squirrel	1
Thomomys bottæ catalinæ, pocket gopher	Mounds
Peromyscus maniculatus rufinus, deer mouse	27
Peromyscus boylii rowleyi, brush mouse	1
Neotoma mexicana bullata, Mexican wood rat	1
Odocoileus couesi, Coues deer	3

Douglas fir characterizes the heaviest forest community of the Santa Catalina Mountains. This community occurs on the northward-facing slopes of some of the upper canyons, notably Marshall Gulch. It is best developed on the high northern slopes of Mount Lemmon (plate 1B).

The most abundant tree of this forest community is the Douglas fir (*Pseudotsuga mucronata*). With Douglas fir is commonly associated Mexican white pine (*Pinus strobiformis*), white fir (*Abies concolor*), and other conifers (Shreve, 1915, 33–35). In favorable locations these and associated species form a heavy forest of large trees.

The slopes in this community are for the most part quite steep. In places a layer of conifer needles covers the ground, but also much bare soil appears,

mostly only thinly covered by grasses and herbs. However, the soil is well filled with humus and it is very dark in color as compared with the light-colored soils of the communities found on the desert not many miles away.

The most common small mammal of the Douglas fir association is the deer mouse, which on the upper slopes of Mount Lemmon is very dark in color. Its color here is much darker than that of the same species near Oracle, only a few miles away, but in a more arid habitat.

Streamside association (*Santa Catalina district*)

Mammals	Records
Procyon lotor subspecies, raccoon	Tracks
Mephitis estor, striped skunk	1
Citellus grammurus grammurus, rock squirrel	1
Eutamias dorsalis dorsalis, cliff chipmunk	4
Thomomys bottæ catalinæ, valley pocket gopher	4
Peromyscus maniculatus rufinus, deer mouse	11
Peromyscus boylii rowleyi, brush mouse	2
Neotoma mexicana bullata, Mexican wood rat	1

In the upper parts of the Santa Catalina Mountains the few streams run in the bottoms of narrow canyons. The conifer forests come to the bottoms of these canyons, and there is only a slight development of a streamside or valley community. Grassy meadows are practically absent. However, in Sabino Canyon near Summerhaven and in a few other upper mountain canyons a small amount of soil has accumulated in places along the canyon bottom, and this soil is much more moist than that on the steep mountain slopes. Here the vegetation is richer than in the bordering yellow pine association, and approaches in part the Douglas fir association. Along the bottom of Sabino Canyon aspens and alders are characteristic, and the shrub poison oak is numerous. In this habitat Dice found the pocket gopher numerous.

Yellow pine association (*Santa Catalina district*)

"The Pine Forest," in Shreve, *op. cit.*, 31–33.

Mammals	Records
Procyon lotor subspecies, raccoon	1
Mephitis estor, striped skunk	1
Urocyon cinereoargenteus subspecies, gray fox	Signs
Citellus grammurus grammurus, rock squirrel	6
Eutamias dorsalis dorsalis, cliff chipmunk	47
Sciurus arizonensis catalinæ, Arizona squirrel	5
Peromyscus maniculatus rufinus, deer mouse	25
Peromyscus boylii rowleyi, brush mouse	31
Neotoma mexicana bullata, Mexican wood rat	5
Odocoileus couesi, Coues deer	Signs

Yellow pine (*Pinus ponderosa*) dominates most of the conifer forest of the upper parts of the Santa Catalina Mountains. This forest grows characteristically in an open stand. A few white pines, a few Douglas firs, and more

rarely some small oak trees may grow among the pines. The mountain slopes are usually very steep and there are numerous outcrops of large granite boulders. The ground commonly is well covered with pine needles, and there is usually a thin growth of grass. Herbs and low shrubs are rare. Rarely in open spots there are small thickets of scrub oaks. Many logs and broken limbs lie on the ground. The soil in general is dark gray in color. The rocks are a rather light-colored granite, but when exposed are well covered by lichens, and are weathered to fairly dark color shades.

The pine forest at its lower border grades fairly gradually into the encinal, and at the lower border of the montane belt isolated pine trees may be found almost surrounded by scrub oaks.

Oak brush association (Santa Catalina district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	1
Eutamias dorsalis dorsalis, cliff chipmunk	1
Neotoma mexicana bullata, Mexican wood rat	1
Sylvilagus species, cottontail	Reported
Odocoileus couesi, Coues deer	Signs

In the upper Santa Catalina Mountains oak brush occurs in isolated patches on exposed south-facing slopes up to elevations of 8000 feet or more. Here there is a thick growth of stunted oaks of several species. No trapping was done in this habitat, but Dice found the cliff chipmunk numerous in this habitat in Carter Canyon, and has sight records of the rock squirrel and of the wood rat. In these patches of oak brush the mountain cottontail, of which no specimens were taken, is reported by forest rangers to occur rarely. We have no doubt that the brush mouse and deer mouse also live in this habitat.

Rock cliff association (Santa Catalina district)

Mammal	Record
Eutamias dorsalis dorsalis, cliff chipmunk	Few

In the upper parts of the Santa Catalina Mountains rock cliffs are not very common, but a few steep rock exposures occur, chiefly on southerly slopes. On these rock exposures, the granite rocks have in general weathered into rounded boulders. Yellow pines and scrub oaks encroach closely on this habitat, and trees eventually dominate it.

We did not make any study of a completely exposed rock cliff habitat, but we have a number of records of mammals trapped around boulders and rock cliffs in yellow pine community. Here the rock squirrel, brush mouse, and wood rat are characteristic.

Aerial association (Santa Catalina district)

Mammals	Records
Myotis volans interior, little brown bat	2
Eptesicus fuscus pallidus, large brown bat	1

Bats seemed to be relatively uncommon in the higher Santa Catalina Mountains during the summer of 1932. In the bottom of Sabino Canyon just below Summerhaven several could usually be seen flying among the trees in the early evenings.

Encinal Belt (Santa Catalina District)

The name "encinal" is adopted from Shreve, who calls this belt on the Santa Catalina Mountains "the encinal region." The oak association characterizes the encinal life belt, and covers a large part of the area included in it. In the bottoms of some of the larger canyons the sycamore association constitutes a minor ecologic type.

The yellow pine association invades the encinal belt from above, especially on sheltered north-facing slopes. From below, the encinal belt is extensively invaded by tongues of arid grassland, and to a much less extent by patches of rock outcrop on which ocotillo association occurs. Some of the patches of arid grassland may even be entirely surrounded by oaks and thereby isolated from the grassland belt. While it would be correct to list the yellow pine association, the grass–mesquite association, and the ocotillo association as minor constituents of the encinal belt, this has seemed unnecessary in view of the narrowness of the belt, and these several communities are described in the life belts in which they are most characteristic.

Sycamore association (Santa Catalina district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	Numerous
Peromyscus eremicus eremicus, cactus mouse	3
Peromyscus boylii rowleyi, brush mouse	4
Sylvilagus audubonii arizonæ, Arizona cottontail	1

In the upper parts of the encinal belt the ravines have very steep slopes, and there is little distinction in vegetation between the bottoms of these ravines and the adjacent oak-covered slopes. Farther down the mountains on their northern slopes, where the ravines have become deep canyons and the gradient is less steep, a characteristic growth of sycamore and walnut occupies the bottom of those canyons in which there is permanent or semi-permanent water. Large gnarled sycamores are the most important tree of the community (plate 2A). This community was studied by Dice mostly in Peppersauce Canyon, about 8 miles southeast of Oracle. Here wild grape vines are numerous, and have completely covered and killed some of the walnuts. A few oaks, apparently invading from the adjacent oak-covered slopes, also occur. There are few shrubs of any kind. The bottom of the canyon is mostly covered by rocks and water-worn gravel, and must be subject to heavy scouring by the occasional freshets. Domestic cattle gather commonly under the shade of these spreading sycamores, and probably have an important effect, through their browsing, in preventing the growth of low vegetation.

Rock squirrels were frequently seen in this habitat, and several brush mice were trapped here.

Over part of the hillside where the automobile road crosses Peppersauce Canyon there is a thicket of mesquite. The presence of this tree is made possible here by a perennially moist condition of the soil due to underground water, which escapes lower down as a spring. In this mesquite thicket rock squirrels were numerous. The cactus mice taken here are probably invaders from the adjacent ocotillo association.

Oak association (Santa Catalina district)

"The Upper Encinal," in Shreve, *The Vegetation of a Desert Mountain Range as Conditioned by Climatic Factors*, Carnegie Inst. Wash. Pub. No. 217, 27–29 (in part), 1915.
"The Lower Encinal," *ibid.*, 25–27 (in part).

Mammals	Records
Citellus grammurus grammurus, rock squirrel	3
Eutamias dorsalis dorsalis, cliff chipmunk	3
Perognathus baileyi baileyi, Bailey pocket mouse	1
Perognathus intermedius intermedius, rock pocket mouse	1
Peromyscus boylii rowleyi, brush mouse	5
Neotoma albigula albigula, white-throated wood rat	2
Lepus alleni alleni, antelope jack rabbit	1
Lepus californicus eremicus, black-tailed jack rabbit	1
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous
Odocoileus hemionus subspecies, mule deer	1

On the north slope of the Santa Catalina Mountains we are unable to find any important difference in the mammals of the oak association between the upper and lower altitudinal limits of the encinal life belt. Desert forms invade the community near its lower limits and montane forms invade the higher elevations, but the general character of the community remains much the same throughout, and it seems undesirable to recognize two associations both dominated by oaks. Perhaps on the southern side of the mountains, where Shreve carried on most of his studies, there may be a different relationship.

Several species of oaks dominate the oak association, forming a forest about 10 to 20 feet in height (plate 1A). Associated with the oaks are occasional junipers and less frequent Spanish bayonets (*Yucca*). Of undershrubs, the fragrant sumac (*Rhus trilobata*) is most common. The manzanita also is common, particularly at higher elevations. The "bear grass" (*Nolina*), agave, and several forms of cactus are numerous. There is a sparse growth of grass and low herbs. The soil on the steep slopes of the oak association is distinctly gravelly, but there is an abundance of clay to bind the material together. The stand of oaks and shrubs is rather open and there is seldom much difficulty in finding a way between clumps of trees.

Aerial association (Santa Catalina district)

Mammals	Records
Eptesicus fuscus pallidus, large brown bat	2
Lasiurus borealis teleotis, red bat	3

Several bats were shot at night as they were flying over open places near the bottom of Peppersauce Canyon near our camp southeast of Oracle. Some bats were seen to fly among the sycamore and walnut trees and perhaps some of the bats taken here might also be considered to be members of the sycamore association.

Grassland Belt (Santa Catalina District)

The belt dominated by grass and shrubby mesquite which lies below the encinal and above the desert is here called the grassland belt. The grassland belt is more extensive on the northern than on the southern side of the Santa Catalina Mountains. Shreve (1915, 23–24) designates this belt "the Upper Desert slopes." On the Santa Catalina Mountains this belt is similar in many ways to the much more extensive belt of grassland lying on the elevated gentle slopes bordering the upper San Pedro River and extending westward to the eastern base of the Huachuca Mountains. A similar arid grassland belt surrounds the Santa Rita Mountains, where it is extensively developed on the northwestern side, the location of the Santa Rita Range Reserve. On the Santa Catalina Mountains the belt is much compressed horizontally, because the slopes of these mountains, especially on their southern side, are much steeper than those of the plains east of the Huachuca Mountains.

The "Lower Desert slopes" of Shreve (1915, 22–23) include the rock hill association, which we place in the Sonoran province, as well as part of the area which we here include in the grassland belt.

The altitudinal range of the grassland belt on the northern slope of the Santa Catalina Mountains, in the vicinity of Oracle, extends from about 3700 to about 4600 feet. On this north slope the mountains are by no means so steep as they are on their southern face; nevertheless the slopes are quite steep, as is shown by the fact that the road between Oracle and Mammoth descends 2166 feet in an air-line distance of 11 miles. On this northern side of the Santa Catalinas there is no sharp physiographic demarcation between mountains and plain, as there is on the southern side at about 2900 feet. The whole region east and southeast of Oracle is well cut with gullies, washes, and canyons, all descending steeply toward the San Pedro River. West of Oracle the topography is less rolling and the ground descends more slowly toward the Canada del Oro, which passes along the western side of the Santa Catalina Mountains.

The upper border of the grassland belt is marked by the coming in of the oaks. However, over a considerable belt of altitude there is an interdigitation between the oaks, which reach their lowest elevations on the northern slopes, and the grassland, which extends far up the mountains on the exposed southerly slopes. We place the average lower boundary of the dominance

of oaks at about 4600 feet, but some extensive patches of oaks descend several hundreds of feet below this level, and likewise patches of typical grassland may be found at elevations of 4700 feet or higher.

The lower boundary of the grassland belt is not sharply marked in the vicinity of Oracle. On the road between Oracle and Mammoth, the first palo verde trees were noted at about 3800 feet, and the first giant cactus at about 3600 feet. However, these species are not dominant until several hundred feet lower. At about 2900 feet elevation, along this road, the vegetation is dominated by sahuaro, palo verde, ocotillo, and cholla cactus, and apparently is the same desert association that occurs on the desert upper bahada on the southern side of the mountains. Shreve notes that both the palo verde and the sahuaro ascend to higher elevations elsewhere in the Santa Catalinas.

Our lowest trapping station along the road between Oracle and Mammoth was at 3750 feet, not far above the highest sahuaro, and in a location where the palo verde, here only a low shrub, was frequent. Grass was common here, and the station is considered to be at the lower edge of the grassland belt.

Mesquite–grass association (Santa Catalina district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	1
Ammospermophilus harrisii harrisii, antelope squirrel	1
Perognathus baileyi baileyi, Bailey pocket mouse	9
Dipodomys ordii ordii, Ord kangaroo rat	1
Onychomys torridus torridus, scorpion mouse	2
Peromyscus eremicus eremicus, cactus mouse	4
Peromyscus maniculatus sonoriensis, deer mouse	1
Neotoma albigula albigula, white-throated wood rat	17
Lepus alleni alleni, antelope jack rabbit	3
Lepus californicus eremicus, black-tailed jack rabbit	8
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous
Odocoileus hemionus subspecies, mule deer	3

The mesquite and grass community covers most of the grassland belt at the north base of the Santa Catalina Mountains. Various thorny shrubs, of which the mesquite is most common, grow in a scattered stand to heights of 4 to 8 feet (plate 3A). There are a few small yucca. The ground between the shrubs is sparsely covered by grass. The grass is mostly of "short" types. A few cacti of several types occur, but the sahuaro is absent. There is much evidence that overgrazing is responsible for the poor stand of vegetation. On the fairly steep slopes which this community covers, loose rocks and gravel are conspicuous elements in the soil, but there is an abundance of sand and clay.

Oak wash association (Santa Catalina district)

Mammals	Records
Perognathus baileyi baileyi, Bailey pocket mouse	3
Dipodomys merriami merriami, Merriam kangaroo rat	1
Peromyscus eremicus eremicus, cactus mouse	1
Peromyscus maniculatus sonoriensis, deer mouse	2
Sylvilagus audubonii arizonæ, Arizona cottontail	1

Oaks and associated shrubs follow down the washes from the encinal belt for a short distance into the grassland belt. A sandy wash about 2½ miles north of Oracle is bordered on each side by thickets of rather tall oaks, catclaw, sumac, yucca, and "bear grass" (*Nolina*).

Trapping here secured a pair of deer mice, which are rare in this belt and absent from the lower desert.

Ocotillo association (Santa Catalina district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	1
Perognathus baileyi baileyi, Bailey pocket mouse	3
Perognathus intermedius intermedius, rock pocket mouse	3
Peromyscus eremicus eremicus, cactus mouse	14
Neotoma albigula albigula, white-throated wood rat	1
Lepus californicus eremicus, black-tailed jack rabbit	2

The ocotillo is a very characteristic plant on rock exposures all over the grassland belt and even extends into the lower edge of the encinal belt. At its higher elevations the plant grows mostly on south-facing slopes. Near our camp at Peppersauce Canyon, patches of rock exposure and rocky slopes covered many acres, and on these rocky areas the ocotillo is the most conspicuous plant. Associated plants are numerous mesquite, a common small agave (*Agave palmeri*), few junipers, rare yucca, and numerous flat-bladed cactus. Grass and low herbs occur in a sparse growth. The growth of the shrubs is quite open. Here the rock pocket mouse and the cactus mouse are common species, just as they are on rocky slopes on the lower desert.

Palo verde–mesquite–grass association (Santa Catalina district)

Mammals	Records
Ammospermophilus harrisii harrisii, antelope squirrel	2
Perognathus amplus taylori, bahada pocket mouse	1
Perognathus baileyi baileyi, Bailey pocket mouse	29
Perognathus intermedius intermedius, rock pocket mouse	5
Dipodomys merriami merriami, Merriam kangaroo rat	1
Onychomys torridus torridus, scorpion mouse	1
Reithrodontomys megalotis megalotis, harvest mouse	1
Peromyscus eremicus eremicus, cactus mouse	2
Peromyscus maniculatus sonoriensis, deer mouse	1
Neotoma albigula albigula, white-throated wood rat	4

The palo verde invades the lower edge of the grassland belt, occurring here only as a shrub. A community of this type was studied by Dice about 5 miles north of Oracle. The elevation at this point is about 3750 feet, and the nearest giant cactus is several hundred feet lower. The slopes are very stony, but there is no rock outcrop. Shrubs of several species, including palo verde, mesquite, and acacia, grow in an open stand. There is a thin growth of grass, both short and medium tall, but not in flower or seed in mid-July, when the station was studied.

Many of the small mammals of the desert were very common at this station. The Bailey pocket mouse in particular was abundant. Wood-rat nests were common and a number of the animals were trapped.

Desert Belt (Santa Catalina District)

Desert conditions extend along the San Pedro Wash for a number of miles. The giant cactus reaches elevations of about 3600 feet on the north slope of the Santa Catalina Mountains. Beginning at about 2900 feet on this slope there occur the giant cactus, the palo verde, frequently the cholla cactus, and more rarely the ocotillo, forming an association apparently identical with that found on the upper bahadas on the south side of the Santa Catalina Mountains. However, on the north side of these mountains the slopes are more gradual than on the south and there is no clear distinction between mountain slopes and desert bahadas. Along the sandy San Pedro Wash, which occupies most of the bottom of a very narrow valley, there is a thick growth of small mesquite. No trapping was done in the desert belt on this north side of the mountains, but it is probable that there is little difference between the mammalian fauna of the desert belt along the San Pedro Wash here and that of the more extensive development of desert on the desert plains near Tucson.

Chíricahua Biotic District

We shall not here attempt to describe the mammalian distribution in the Chíricahua Mountains, for they were visited only briefly by Blossom. Victor H. Cahalane, who worked in these mountains in cooperation with the Carnegie Institution of Washington surveys, has in preparation an extended report on the mammals.

Huachuca Biotic District

The Huachuca (pronounced wa-chú-ka) biotic district includes the Huachuca Mountains, which lie on the Mexican border, and also the surrounding area of arid grassland. The Huachuca Mountains rise from the high plain, which at the eastern base of the mountains has an elevation of about 5000 feet. These mountains are moderately high, their highest peaks reaching well over 9000 feet. Dice studied the region near the mouth of Miller Canyon for the period July 20 to August 5, 1932. This canyon is on the eastern side of the range, only about 6 miles north of the Mexican boundary.

It is possible that several life belts should be recognized on the Huachuca Mountains, but the distinction between the encinal belt and the montane forest belt is much less clear here than on the Santa Catalinas. In this paper we shall consider the Huachuca Mountains to be covered by a single life belt, the forest belt.

Oak forest extends downward to the eastern base of the mountains and even extends in places over the adjacent plain for distances up to a mile or more. However, some of the lower hills are bare of oaks, so that the lower

edge of the oak forest is an irregular line. Pines of several species appear among the oaks only a few hundred feet above their lower edge, and a mixed forest of pines, oaks, and other trees continues upward to the summits of the highest peaks. Time did not permit a study of the upper mountains.

Forest Belt (Huachuca District)

Our study of the Huachuca Mountains involved only the ecologic communities at the lower edge of the forest near the mouth of Miller Canyon and along the lower part of the canyon. No observations were made of the flora or fauna at elevations above 6500 feet. At the mouth of Miller Canyon the oak hill and oak plain associations are the most widespread communities, but a heavier growth of trees is found in the sycamore association along the bottom of the canyon.

Sycamore association (Huachuca district)

Mammals	Records
Sciurus arizonensis huachuca, Arizona squirrel	3
Peromyscus maniculatus sonoriensis, deer mouse	1
Peromyscus boylii rowleyi, brush mouse	11
Sigmodon hispidus cienegæ, cotton rat	3

The narrow bottom of Miller Canyon, upward at least to an elevation of about 5900 feet, supports a thin stand of sycamores and walnuts. This community follows the watercourse down for a quarter-mile or so upon the wide-spreading alluvial fan at the mouth of the canyon. Water flows permanently in this canyon, but disappears quickly into the ground when the stream reaches its alluvial fan. Low shrubs are abundant in this association, notably poison oak (*Rhus*).

In a fenced field on the nearly level floor of the valley just at the mouth of Miller Canyon the grass, owing to a reduced amount of grazing, is much more abundant and taller than elsewhere in the region. Here there is an open stand of fairly large oaks, with a few sycamores and walnuts along the ravine. There are a few manzanita. As this is on the flood-plain of the stream, many large stones and boulders are scattered about, and some of these have been gathered into piles and into a broken-down stone fence. Along this fence several cotton rats were trapped.

In the sycamore association the Arizona squirrel is rare, but its scarcity may indicate extensive hunting. The brush mouse is common.

Oak plain association (Huachuca district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	Numerous
Citellus spilosoma canescens, spotted spermophile	1
Thomomys bottæ extenuatus, pocket gopher	2
Peromyscus maniculatus sonoriensis, deer mouse	1
Peromyscus boylii rowleyi, brush mouse	18

The oak forest, which at the mouth of Miller Canyon covers most of the lower hills, extends in places down over the gently sloping plain which borders the bases of the mountains for a mile or more. The plain is, at the mouth of Miller Canyon, mostly the enormous alluvial fan which radiates out from the canyon, and the soil is a mixture of clay and sand or small gravel, with only rare stones on the surface.

The oak forest on this alluvial fan grows in an open stand, and it is not at all difficult to walk between the trees. They attain heights up to about 25 feet. The ground is covered with a fairly good stand of short grass and a number of herbs, among which in early August the perennial flax is very conspicuous. There are a few shrubs of manzanita and a few prickly-pear and cholla cacti.

The rock squirrel is a conspicuous animal of this community, although it is more common on the nearby rocky slopes. The brush mouse is numerous.

Oak hill association (Huachuca district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	Numerous
Perognathus intermedius intermedius, rock pocket mouse	6
Peromyscus boylii rowleyi, brush mouse	15
Neotoma albigula albigula, white-throated wood rat	3
Sylvilagus floridanus holzneri, Huachuca cottontail	Few
Sylvilagus audubonii arizonæ, Arizona cottontail	1
Odocoileus couesi, Coues deer	2

A low forest of oaks covers most of the lower hills and mountain slopes at the mouth of Miller Canyon. Large rocks are common on the steep slopes, and rock outcrops are numerous. However, even on the steepest slopes, except on actual rocky ledges, there is a considerable amount of clay soil so that plants have an adequate foothold. On the steep slopes the oak trees tend to be rather small and to grow in thickets. However, there are many open places. Growing with the oaks there are a few small mesquites and other small trees and shrubs. There are also a few of the shrubby manzanita. Agaves are numerous and so is *Senecio longilobus*. Grass occurs in a thin growth.

Aerial association (Huachuca district)

Mammal	Record
Pipistrellus hesperus merriami, canyon bat	1

From the aerial association of the Huachuca forest belt we have only the record of one canyon bat, which was shot as it was flying among the oaks on the plain at the mouth of Miller Canyon.

Grassland Belt (Huachuca District)

The extensive plain which slopes eastward from the base of the Huachuca Mountains down to the San Pedro River is dominated by grassland. In a

distance of about 9 miles, from the mouth of Miller Canyon to the San Pedro River at Hereford, there is a drop in elevation of over 900 feet.

Over most of this plain the dominant vegetation is arid grass in which grow scattered mesquite bushes. Along the base of the Huachuca Mountains near the mouth of Miller Canyon, however, there is a strip about 2 miles wide in which mesquite is largely absent. A few washes cross the plain toward the river, but these are all shallow and seem not to have much influence on the character of the vegetation, though in the *Senecio* association the shrubs grow taller along the washes. Along the flood-plain of the San Pedro River there are some groves of willow and poplar and some fields of a coarse grass which grows in large clumps. The river lies in a broad trench which is perhaps 75 feet below the edge of the plain. Just above the rim of the trench, perhaps a little more than a half-mile west of the river, there is an irregular belt of Spanish bayonets (*Yucca*) and thorny shrubs.

Cottonwood–willow association (Huachuca district)

Cottonwoods and willows occur in scattered groves along the San Pedro River at Hereford (plate 3B). The cottonwoods make fairly tall trees, but the willows are not so conspicuous. Under the shade of the trees there is little vegetation. The soil is of fine alluvium and on the flood-plain of the river the ground must occasionally be covered by water. Although Dice set a number of mouse traps in this habitat, he failed to secure any mammals.

Sacaton association (Huachuca district)

Mammals	Records
Perognathus hispidus paradoxus, plains pocket mouse . . .	1
Perognathus penicillatus pricei, sand pocket mouse	3
Onychomys leucogaster ruidosæ, grasshopper mouse	2
Peromyscus leucopus arizonæ, white-footed mouse	12
Sylvilagus audubonii arizonæ, Arizona cottontail	3

Along the San Pedro River near Hereford there are occasional patches of a coarse tall grass (*Sporobolus wrightii*) which grows in thick clumps (plate 3B). Although the community occupies low ground along the river bank, it is probably above the reach of most floods. Small gullies are numerous. The soil is a fine alluvium, which after a rain becomes quite muddy. In this community there are a few widely separated small trees of mesquite, willow, and cottonwood. Among the large clumps of grass there are few herbs or other types of grass.

In this community the white-footed mouse was common and characteristic, and several species of other small mammals were taken, making the community one of the most populous in mammals of the whole region.

Catclaw–mesquite association (Huachuca district)

Mammals	Records
Citellus spilosoma canescens, spotted spermophile	1
Perognathus penicillatus pricei, sand pocket mouse	3
Dipodomys ordii ordii, Ord kangaroo rat	1
Onychomys leucogaster ruidosæ, grasshopper mouse	6
Reithrodontomys megalotis megalotis, harvest mouse	1
Peromyscus leucopus arizonæ, white-footed mouse	4
Sigmodon hispidus cienegæ, cotton rat	2
Neotoma albigula albigula, white-throated wood rat	3

The western bank of the San Pedro River at Hereford is somewhat higher than the eastern bank, and just north of the road, which here runs east and west, there is a narrow belt of sandy and gravelly soil which is covered by a fairly thick stand of catclaw and mesquite. In places there are a number of clumps of coarse sacaton grass and a few *Ephedra*. There is a thin stand of short grass in the open spots. Immediately to the west of this narrow belt the ground rises in a gentle slope and the habitat becomes more arid, mesquite and short grass being the dominant vegetation. We are of the opinion that this station represents something of a mixture of communities and that it is not quite typical of the catclaw–mesquite association, if a typical community of this character does actually occur along the river here. Nevertheless, the assemblage of mammals taken in this situation is somewhat different from that secured in any other of the adjacent communities, and until more is known about the ecology of this region the community may be recognized as distinct.

Senecio association (Huachuca district)

Mammals	Records
Citellus grammurus grammurus, rock squirrel	1
Citellus spilosoma canescens, spotted spermophile	1
Thomomys bottæ extenuatus, pocket gopher	1
Perognathus flavus flavus, Baird pocket mouse	4
Perognathus hispidus paradoxus, plains pocket mouse	2
Perognathus penicillatus pricei, sand pocket mouse	1
Onychomys leucogaster ruidosæ, grasshopper mouse	1
Reithrodontomys megalotis megalotis, harvest mouse	2
Reithrodontomys fulvescens fulvescens, harvest mouse	2
Reithrodontomys species, harvest mouse	2
Peromyscus maniculatus sonoriensis, deer mouse	13
Peromyscus boylii rowleyi, brush mouse	1

The low shrub *Senecio longilobus* occurs frequently in many of the communities of the grassland belt east of the Huachuca Mountains, but is most abundant at the upper edge of the plain, near the base of the mountains. The identification of this plant was made by Dr. John Ehlers. At the mouth of Miller Canyon *Senecio* dominates extensive areas, which are more or less continuous along the eastern base of the mountains. In places where the shrub has not been destroyed by clearing or overpasturage it forms a fairly

thick stand, with bushes reaching about 3 feet in height. It is particularly luxuriant next to the base of the mountains along the small washes which traverse the plain. Some grass, of both tall and short types, grows with the *Senecio*, and where the shrub grows thinly the grasses dominate. Among the shrubs there may be a few prickly-pear cacti, especially in overgrazed areas.

Grass–mesquite association (Huachuca district)

Mammal	Record
Sigmodon minimus minimus, cotton rat	4

A large part of the plain sloping from the mouth of Miller Canyon to the San Pedro River at Hereford is dominated by mixed short and tall grasses, but with a widely spaced stand of small mesquite trees and shrubs. The growth of grass and other vegetation is considerably more luxuriant than in the similar community found on the north slopes of the Santa Catalina Mountains at about the same elevation. Probably the more gentle slopes drain less rapidly and their soil is less coarse and more retentive of moisture. It is also likely that there is a somewhat greater rainfall on the eastern side of the Huachuca Mountains than north of the Santa Catalina Mountains, which is nearer the desert belt.

Dice studied this community only at a single station, about $3\frac{1}{2}$ miles west of Hereford at an elevation of 4350 feet. At this place *Senecio longilobus* was numerous, overtopping the short grass, and there were also numerous herbs. The soil is a red clay. Here the cotton rat (*Sigmodon minimus*) was numerous, making many runways in the grass.

Yucca association (Huachuca district)

Mammal	Records
Perognathus hispidus paradoxus, plains pocket mouse	1
Perognathus penicillatus pricei, sand pocket mouse	2
Dipodomys merriami merriami, Merriam kangaroo rat	4

A belt of Spanish bayonets and thorny shrubs is found just above the edge of the trench in which the San Pedro River flows, and about $\frac{1}{2}$ mile west of the river. The sandy soil here, owing to the presence of the adjacent moderately steep slope, is better drained than the part of the plain which lies farther away from the river. Thorny shrubs of several species and yuccas grow in a scattered stand. A few *Ephedra* were noted. The space between the shrubs is covered by a sparse stand of short grass.

Mounds of kangaroo rats were very numerous in this community and several individuals were trapped at the mounds.

Santa Rita Biotic District

The Santa Rita district includes the Santa Rita Mountains and the adjacent grassland belt, the Patagonia Mountains, and a considerable extension to the westward, including, in the United States, the Tumacacori Mountains and

the Baboquivari Mountains. West of the Baboquivari Mountains the elevation drops off rapidly, and desert covers their western base. Between the Baboquivari and Tumacacori Mountains there is a considerable extent of high grassland, which must be placed in the Chihuahuan province rather than in the Sonoran. The Sonoran desert extends up the Santa Cruz Valley for some distance beyond Continental, and the connection between the part of the Santa Rita district east of the Santa Cruz River and that to the west of the river occurs mostly at the higher elevations toward and south of the Mexican boundary. Dice and Harris passed through the grassland area near Sasabe, but neither of us has worked in the Tumacacori Mountains. The close similarity between the ecologic conditions of the lower part of the Santa Rita Mountains and those of the Tumacacori and Baboquivari Mountains has been pointed out to us by Burt.

The western base of the Santa Rita Mountains is considered by both Swarth (1929, 270) and Gloyd (1932, 110) to be an important faunal boundary separating the Eastern Plains area from the desert. In our interpretation of the biogeographical relationships in this region we place this division farther west, at the western base of the Baboquivari Mountains. Such a westward extension of the bird fauna of the arid grassland was suggested by Law (1929, 218).

Encinal Belt (Santa Rita District)

The Tumacacori and adjacent mountains do not rise high enough to support forests of pine, but they do support oak encinal on their upper slopes. Burt (1933, 121) took the Huachuca cottontail (*Sylvilagus floridanus holzneri*) on a grassy ridge in encinal belt on the Atasco Mountains (which according to the Geological Survey maps are a part of the Tumacacori Mountains). The Baboquivari Mountains are even more arid than the Tumacacori, but they also support a number of oaks on their upper slopes.

The grassland belt is well represented in the Santa Rita district, but the encinal belt and the montane belt are, owing to the relatively small mass of high mountains in the Santa Ritas, less well developed than in the Santa Catalina Mountains.

Blossom collected for two weeks in the Santa Rita Mountains in Madera Canyon. He also did some trapping on the Santa Rita Range Reserve, which lies to the northwest of the mountains. Dice collected only for a single night on the Range Reserve. Our information about the Santa Rita District is therefore meager, and we make no attempt to describe all the ecologic associations of the district.

Sycamore association (Santa Rita district)

Mammals	Records
Bassariscus astutus arizonensis, bassarisk	4
Spilogale species, spotted skunk	1
Mephitis estor, striped skunk	3
Conepatus mesoleucus venaticus, hog-nosed skunk	5
Citellus grammurus grammurus, rock squirrel	3

Blossom did most of his collecting in the Santa Rita Mountains in the bottom of Madera Canyon and in some of its small tributary canyons. Here the dominant tree species is the western sycamore, but oaks also are common and the walnut is frequent. There are a few madroña (*Arbutus arizonica*). The shrubby manzanita is numerous in the undergrowth.

Oak association (*Santa Rita district*)

Mammals	Records
Peromyscus boylii rowleyi, brush mouse	3
Neotoma albigula albigula, white-throated wood rat	1
Sylvilagus floridanus holzneri, Huachuca cottontail	Reported

The oak association is well developed on the lower slopes of the Santa Rita Mountains, where it appears to be similar to the same type of association on the northern slopes of the Santa Catalina Mountains.

Grassland Belt (*Santa Rita District*)

A broad belt of grassland covers the gently sloping plain which lies to the west and northwest of the Santa Rita Mountains. The upper edge of the grassland is the lower edge of the oak forest, a rather sharp but somewhat sinuous line. The lower edge of the grassland belt is less sharply defined, for there is a somewhat gradual transition to the desert.

The most widespread association of the grassland belt of the Santa Rita district is characterized by the dominance of grass and mesquite. Along the shallow washes which traverse the belt the mesquite grows more closely together and the individual trees are taller than on the open plain. A few small hills rise above the general level of the plain and produce a rocky slope community, but these rocky slopes were not studied by us.

Wash association (*Santa Rita district*)

Mammals	Records
Lepus alleni alleni, antelope jack rabbit	Few
Lepus californicus eremicus, black-tailed jack rabbit	Numerous

The washes which we saw in the upper part of the grassland belt in the Santa Rita Range Reserve are rather shallow and broad, and there is no sharp distinction between the washes and the adjacent grass–mesquite association. The washes are more sandy than the rest of the plain, and in them the mesquite grows larger and more thickly together than elsewhere on the grassland belt. We did not trap in this association and have only a few sight records of mammals.

Grass–mesquite association (Santa Rita district)

Mammals	Records
Lynx rufus subspecies, bobcat	1
Citellus tereticaudus neglectus, round-tailed spermophile	17
Ammospermophilus harrisii harrisii, antelope squirrel	1
Perognathus baileyi baileyi, Bailey pocket mouse	8
Perognathus penicillatus pricei, sand pocket mouse	1
Dipodomys spectabilis, banner-tailed kangaroo rat	3
Dipodomys merriami merriami, Merriam kangaroo rat	18
Onychomys torridus torridus, scorpion mouse	5
Neotoma albigula albigula, white-throated wood rat	4
Lepus alleni alleni, antelope jack rabbit	11
Lepus californicus eremicus, black-tailed jack rabbit	Few
Sylvilagus audubonii arizonæ, Arizona cottontail	3

Blossom and Dice both studied briefly the grass and mesquite association on the Santa Rita Range Reserve near the experimental plots of Vorhies. Here the soil is rather sandy and there are a considerable number of mounds of kangaroo rats. Round-tailed ground squirrels, white-throated wood rats, and antelope jack rabbits are also common.

Isocoma association (Santa Rita district)

Mammals	Records
Citellus tereticaudus neglectus, round-tailed spermophile	2
Dipodomys merriami merriami, Merriam kangaroo rat	5
Onychomys torridus torridus, scorpion mouse	3
Lepus alleni alleni, antelope jack rabbit	Reported
Odocoileus hemionus subspecies, mule deer	1

On slopes of the Santa Rita Range Reserve, 25 miles south of Tucson and at about 2900 feet elevation, occurs an extensive development of a low shrub. Blossom, who studied this community January 10 to 11, 1931, did not collect any specimens of this shrub, but Shreve feels fairly certain that the plant in question is *Isocoma hartwegi* (sometimes called *Aplopappus hartwegi*). In this community the soil is sandy and there is little grass, but the desert hackberry and the cholla cactus (*Opuntia*) are numerous.

SONORAN BIOTIC PROVINCE

The Sonoran biotic province (Dice, unpublished manuscript) is most characteristically developed in the state of Sonora, Mexico, along the eastern side of the Gulf of California. It reaches Arizona in a somewhat modified form, a number of its types of cacti and other desert plants not occurring so far northward. It covers also a large part of southeastern California. The Sonoran biotic province corresponds closely to the *Larrea–Franseria* association or western desert scrub of Clements (1920, 170–177).

The Sonoran province throughout its whole extent is made up of desert plains, from which rise numerous isolated desert mountains. The materials eroded from the mountains are spread out from their bases, forming bahadas,

which largely constitute the plains. The desert plains are not of uniform level, but slope gradually upward toward every mountain and downward toward the sea or toward the larger rivers and washes.

The part of the Sonoran biotic province lying in southwestern Arizona and northwestern Sonora is more arid than the part around Tucson. A number of the subspecies of mammals are different in the two areas, as is pointed out in a later section of this report. Gloyd (1932, 109–110) has pointed out differences in the reptiles and amphibians from the two areas and has recognized a Central Desert Area as distinct from a Western Desert Area, which is the Western Desert Tract of Mearns (1907, 74). Gloyd places the dividing line between the Central and Western Desert Areas near Ajo. These terms are not very satisfactory when it is considered that the Sonoran desert extends far west of Arizona in California. The Central Desert Area of Gloyd is recognizable and should rank as a biotic district of the Sonoran province, but a better designation is desirable. We suggest the name Tucson biotic district. For the Western Desert Tract of Mearns (Western Desert Area of Gloyd) we propose the name Yuma biotic district.

Tucson Biotic District

The Tucson biotic district is the eastern part of the Sonoran province in Arizona. Although its climate and vegetation are distinctly desert-like, it is less arid than the Yuma district to the westward. Its western boundary in Arizona extends from about Gila Bend southward to Ajo. From Ajo it extends eastward to the western base of the Baboquivari Mountains, around the northern end of which it passes, and it continues on to the east around the northern end of the Tumacacori Mountains. An extensive arm extends up the Santa Cruz Valley. It occupies the broad desert valley in which the city of Tucson lies, and encroaches on the lower southern and western slopes of the Santa Catalina Mountains. Its boundaries to the northwest are unknown.

Aquatic association (Tucson district)

"Association of Aquatics," in Ruthven, *A Collection of Reptiles and Amphibians from Southern New Mexico and Arizona*, Bull. Amer. Mus. Nat. Hist., vol. 23, 502, 1907.

"Association of Hygrophytes," in Spalding, *Distribution and Movements of Desert Plants*, Carnegie Inst. Wash. Pub. No. 113, 7, 1909.

Some permanent streams reach the upper edge of the desert near Tucson, notably Sabino Creek. Temporary streams occupy the various washes during periods of rain. Toads and some other animals are able to breed and mature their larvæ in the ephemeral desert pools. No mammals live in the aquatic association, but some drink at the pools and streams when water is available.

Cottonwood–willow association (Tucson district)

"Willow–Poplar Association," in Ruthven, *op. cit.*, 502.
"Association of Cottonwoods and Willows," in Spalding, *op. cit.*, 809.

Mammals	Records
Citellus grammurus grammurus, rock squirrel	2
Citellus tereticaudus neglectus, round-tailed spermophile	1
Perognathus flavus flavus, Baird pocket mouse	1
Perognathus penicillatus pricei, sand pocket mouse	4
Dipodomys merriami merriami, Merriam kangaroo rat	5
Onychomys torridus torridus, scorpion mouse	Reported
Reithrodontomys megalotis megalotis, harvest mouse	Reported
Reithrodontomys fulvescens fulvescens, harvest mouse	Reported
Peromyscus eremicus eremicus, cactus mouse	8
Peromyscus maniculatus sonoriensis, deer mouse	Reported
Peromyscus leucopus arizonæ, white-footed mouse	Reported
Peromyscus boylii rowleyi, brush mouse	Reported
Sigmodon hispidus cienegæ, cotton rat	Reported
Neotoma albigula albigula, white-throated wood rat	1
Mus musculus musculus, house mouse	1

There are thickets of willows and small groves of cottonwoods in a few places along the banks of the Santa Cruz River and of the Rillito Wash near Tucson. These trees must originally have been much more widespread than they are now, for there are evidences of cutting and trimming by man in many of the few remaining groves. Bordering Rillito Wash at Fort Lowell, 7 miles northeast of Tucson, are many willows and large cottonwoods. Blossom trapped here January 17 to 23, 1931. In several places the cottonwoods grow close together to form small groves, under which the ground is nearly devoid of vegetation, but for the most part these trees form only a broken fringe along the edge of the wash. On the flood-plain away from the shade of the larger trees, there is a growth of low shrubs, the most conspicuous of which are *Baccharis viminea* and *Hymenoclea monogyra*. Growths of these plants occur mostly as isolated clumps, with areas of bare sand between. The soil is of fine texture and, where our sample was taken a short distance back from the edge of the wash, is of a somewhat dark color. The fringe of cottonwoods and willows along the edge of the wash is so thin that we have not attempted to discriminate in our trapping between the mammals taken among these trees and those taken in the adjacent low brush. Under more natural conditions it is probable that the mesquite forest association would adjoin the cottonwoods and willows, but the mesquite trees have been cut away and only a few small individuals remain on somewhat higher ground near by.

We have also a few records of mammals secured by Burt at Continental and Tumacacori Mission.

Mesquite forest association (Tucson district)

"Mesquite Association," in Ruthven, *op. cit.*, 502.
"Mesquite Forest Association," in Spalding, *op. cit.*, 2–12.

Mammals	Records
Canis latrans subspecies, coyote	Signs
Ammospermophilus harrisii harrisii, antelope squirrel	Reported
Perognathus baileyi baileyi, Bailey pocket mouse	1
Perognathus penicillatus pricei, sand pocket mouse	30
Dipodomys spectabilis perblandus, banner-tailed kangaroo rat	Reported
Dipodomys merriami merriami, Merriam kangaroo rat	4
Onychomys torridus torridus, scorpion mouse	1
Peromyscus eremicus eremicus, cactus mouse	2
Lepus alleni alleni, antelope jack rabbit	Reported
Lepus californicus eremicus, black-tailed jack rabbit	Reported
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous

The mesquite is widespread over the whole desert region, and reaches considerable elevations on the slopes of the mountains. It occurs in many different types of habitats in the Tucson region, but it is best developed on the flood-plains of the rivers and of the larger washes. A large part of the flood-plain near Tucson is said by Spalding originally to have been covered by a forest of this type, with which were associated sacaton grass and even tules in springy places. Near Tucson practically the whole of the association has been destroyed, and only some modified fragments remain along the Santa Cruz River and elsewhere.

The mesquite forest association was studied by Dice in April 1930 in a low area about 5 miles northwest of Robles Ranch, or about 25 miles southwest of Tucson. The elevation is about 2500 feet. The soil here is a fine sandy silt and no gravel or rocks are exposed. There are numerous small and medium-sized washes, which are easily eroded in the light soil. Some of the washes are nearly straight-sided gullies cut as much as 10 feet below the general level of the ground. Mesquite is the dominant plant, but the larger trees have been artificially removed and the forest growth is sparse. Several thorny shrubs are abundant.

Desert wash association (Tucson district)

"Acacia Association," in Ruthven, *op. cit.*, 502.
"Palo Verde–Catclaw Association," in Spalding, *op. cit.*, 14.

Mammals	Records
Perognathus amplus taylori, bahada pocket mouse	Reported
Perognathus baileyi baileyi, Bailey pocket mouse	2
Perognathus penicillatus pricei, sand pocket mouse	8
Perognathus intermedius intermedius, rock pocket mouse	1
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous

The small and medium-sized washes which drain from the various mountain ranges and pass downward across the bahadas to the desert plain constitute a community more or less intermediate between the mesquite forest

of the lower plain and the upper bahada association with sahuaro, ocotillo, and palo verde dominant. These washes usually have a fairly steep gradient, and while their beds may in places be filled with sand, in other parts gravel or even boulders may be conspicuous. The vegetation bordering these washes consists to a large extent of catclaw, mesquite, and palo verde.

A wash of this type descending across the upper bahada at the south base of the Santa Catalina Mountains and located about 8 miles north of Tucson was studied by Dice in April 1930.

Salt bush association (Tucson district)

"Association of Salt-Bushes," in Spalding, *op. cit.*, 13.

Some areas of alkaline soil occur along the Santa Cruz Valley below Tucson. The vegetation on these areas consists mostly of a thin growth of alkali-tolerant plants. Most of these areas have been much modified by attempts at cultivation and no study was made of the mammals of this association.

Cholla–mesquite–hackberry association (Tucson district)

Mammals	Records
Citellus tereticaudus neglectus, round-tailed spermophile	13
Ammospermophilus harrisii harrisii, antelope squirrel	7
Perognathus penicillatus pricei, sand pocket mouse	6
Dipodomys merriami merriami, Merriam kangaroo rat	3
Onychomys torridus torridus, scorpion mouse	1
Neotoma albigula albigula, white-throated wood rat	2
Lepus alleni alleni, antelope jack rabbit	Few
Lepus californicus eremicus, black-tailed jack rabbit	Few

An extensive area about 10 to 16 miles south of Tucson, on the desert plain south of Black Mountain, has been heavily overgrazed and overbrowsed and is now covered thinly by several species of cholla cactus (arborescent *Opuntia*), small shrubby mesquites, and clumps of desert hackberry. There are a considerable number of prickly-pear cactus, and rarely a palo verde tree. On the ground there is a sparse cover of low shrubs, herbs, and grass. The soil is sandy and apparently very deep, for the situation is on a low bahada of the Sierrita Mountains. The slope is very gentle. The station was studied by Blossom at various times from January to March 1931. In this situation burrows of ground squirrels and kangaroo rats are numerous, but wood-rat homes were not observed.

Creosote bush association (Tucson district)

"Creosote Bush Association," in Ruthven, *op. cit.*, 502.
"Creosote-Bush Association," in Spalding, *op. cit.*, 16.

Mammals	Records
Canis latrans subspecies, coyote	Signs
Citellus tereticaudus neglectus, round-tailed spermophile	3
Ammospermophilus harrisii harrisii, antelope squirrel	1
Perognathus amplus taylori, bahada pocket mouse	8

Mammals	Records
Perognathus baileyi baileyi, Bailey pocket mouse	6
Perognathus penicillatus pricei, sand pocket mouse	25
Dipodomys spectabilis perblandus, banner-tailed kangaroo rat	Reported
Dipodomys merriami merriami, Merriam kangaroo rat	11
Onychomys torridus torridus, scorpion mouse	1
Lepus alleni alleni, antelope jack rabbit	Few
Lepus californicus eremicus, black-tailed jack rabbit	Few
Sylvilagus audubonii arizonæ, Arizona cottontail	Few

The creosote bush (*Larrea tridentata*) is characteristic of the gently sloping lower bahadas. The community is rather sharply defined from the floodplain of the rivers and washes, though on very gentle slopes near Robles Ranch there are places where creosote bush and mesquite occur mixed together.

Where the community is best developed, creosote bush forms almost a pure stand, with shrubs growing widely spaced in a stand like a miniature orchard. The usual height of the bushes is about 5 or 6 feet. Several species of arborescent cacti (*Opuntia* spp.), locally called "cholla," and *Acacia paucispina* occur in places with the creosote bush. A sparse growth of grass does not suffice to cover the ground.

The soil in this community is usually a fine sand or silt. Layers of *caliche* hardpan may occur under the surface or even in places may be exposed (Shreve and Mallery, 1933, 111). These hardpan layers undoubtedly have an influence on the occurrence of some of the burrowing rodents, and may prevent the occurrence of some species of plants.

Franseria association (Tucson district)

"Franseria Association," in Spalding, *op. cit.*, 17.

The *Franseria* association described by Spalding occurs on the gentle slopes of the Desert Laboratory grounds west of Tumamoc Hill. Neither of us made any intensive study of this habitat and we therefore cannot give a list of its mammals, nor are we able to place it in any of our other communities. We suspect that it is most closely related to the creosote bush association, but its cover of vegetation is different. Spalding states that the dominant plants are *Franseria deltoidea* and *Opuntia fulgida.*

Palo verde–brittlebush association (Tucson district)

Mammals	Records
Perognathus amplus taylori, bahada pocket mouse	3
Perognathus baileyi baileyi, Bailey pocket mouse	5
Dipodomys merriami merriami, Merriam kangaroo rat	1
Neotoma albigula albigula, white-throated wood rat	Houses
Lepus californicus eremicus, black-tailed jack rabbit	Few
Sylvilagus audubonii arizonæ, Arizona cottontail	Few

About 8 miles north of Tucson, where Dice studied the community in 1930, the common low shrub is the brittlebush (*Encelia farinosa*), forming a very open growth about 2 feet high. The palo verde (*Parkinsonia microphylla*) is common as a small tree, much scattered in stand. At this place there are a few sahuaro (*Carnegiea gigantea*), a few cholla cactus, a few barrel cactus, and a few acacia, and on the ground is a sparse growth of grasses. The soil is composed of small gravel and sand, and large stones are rare.

The surface soil on the middle bahada at this place not only is much finer in texture than on the upper bahada, but seems to be much deeper, and therefore would seem to be more suitable for some kinds of small burrowing mammals than either the upper bahada, which is more or less covered by rocks, or the lower bahada, where *caliche* may form an impervious area just below the surface of the ground.

Upper bahada association (Tucson district)

"Suaharo-Ocotillo Association," in Ruthven, *op. cit.*, 502.

"Upper Bahadas," in Shreve, *The Vegetation of a Desert Mountain Range as Conditioned by Climatic Factors*, Carnegie Inst. Wash. Pub. No. 217, 16–19, 1915.

Mammals	Records
Spilogale species, spotted skunk	Tracks
Canis latrans subspecies, coyote	Signs
Citellus tereticaudus neglectus, round-tailed spermophile	2
Ammospermophilus harrisii harrisii, antelope squirrel	9
Perognathus amplus taylori, bahada pocket mouse	2
Perognathus baileyi baileyi, Bailey pocket mouse	23
Perognathus intermedius intermedius, rock pocket mouse	3
Neotoma albigula albigula, white-throated wood rat	2
Lepus alleni alleni, antelope jack rabbit	Few
Lepus californicus eremicus, black-tailed jack rabbit	Few
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous
Odocoileus hemionus subspecies, mule deer	Reported
Odocoileus couesi, Coues deer	Signs

The upper slopes of the bahadas, where these approach the bases of the mountains, are usually made up of soil of all degrees of fineness, from clay to large boulders. Rock outcrops occur frequently if the slope is at all steep, and at many places the soil must be very shallow. However, many alluvial fans are included as a part of these bahadas, and in places the soil is probably very deep.

The vegetation of the upper bahadas of the Tucson region has been well described by Shreve. The most conspicuous plants of the upper bahadas at the south base of the Santa Catalina Mountains (plate 4A), where the association was studied by Dice in 1930, are the sahuaro (*Carnegiea gigantea*), the palo verde (*Parkinsonia microphylla*), and the ocotillo (*Fouquieria splendens*). Associated with these large plants are a number of smaller shrubs, of which the brittlebush (*Encelia farinosa*) is conspicuous. The stand of vegetation is very open and one may walk nearly anywhere between the plants. Under the stimulus of the water brought by the winter or summer

rains a number of herbs and grasses pass rapidly through their brief life cycles, then wither again and become dormant or die.

Rock hill association (Tucson district)

"Association of Fouquieria and Parkinsonia microphylla," in Spalding, *op. cit.*, 18
"Association of Cereus giganteus and Encelia farinosa," *ibid.*, 18.
"Lippia Association," *ibid.*, 19.
"Hyptis-Nicotiana Association," *ibid.*, 19.

Mammals	Records
Bassariscus astutus arizonensis, bassarisk	Numerous
Spilogale species, spotted skunk	Reported
Vulpes macrotis macrotis, desert fox	2
Citellus grammurus grammurus, rock squirrel	3
Ammospermophilus harrisii harrisii, antelope squirrel	5
Perognathus baileyi baileyi, Bailey pocket mouse	2
Perognathus penicillatus pricei, sand pocket mouse	2
Perognathus intermedius intermedius, rock pocket mouse	57
Perognathus intermedius nigrimontis, rock pocket mouse	88
Onychomys torridus torridus, scorpion mouse	1
Peromyscus eremicus eremicus, cactus mouse	51
Peromyscus eremicus pullus, cactus mouse	24
Sigmodon hispidus cienegæ, cotton rat	1
Neotoma albigula albigula, white-throated wood rat	10
Sylvilagus audubonii arizonæ, Arizona cottontail	Numerous
Pecari angulatus sonoriensis, peccary	Signs
Odocoileus couesi, Coues deer	1

All the communities of the rock slopes and rock cliffs of the desert region are here combined as one association. There are, it is true, important differences in the vegetation correlated with slope exposure, steepness of slope, and probably with the character of the underlying rock. Doubtless the several plant associations described by Spalding from the rock hill can be recognized as important minor communities.

Conspicuous plants of the rock hill are the giant cactus, palo verde, and ocotillo. The low gray brittlebush (*Encelia farinosa*) is common where soil has accumulated among the rocks.

The rock hill is covered more or less completely with large and small blocks of loose rock, some being boulders of large size. Ledges of undetached rock also occur in places and small cliffs of rock often are found in this habitat (plate 4B). The nature of the rock may be igneous or sedimentary, and the rapidity with which the rock is decomposed has considerable influence on the size of the rock fragments, the color of the soil, and the steepness of the slope.

The rock hill constitutes a very distinct community of mammals, and the same species seem to occur, even on isolated rock hills or mountains, wherever steep rocky slopes occur. The heaps of rocks obviously are splendid situations for the homes of small mammals. Species most characteristic of this community are the rock pocket mouse, cactus mouse, and white-throated wood rat. The rock pocket mouse seems to be almost entirely

restricted to this type of habitat. The cactus mouse is less closely restricted to the rock hill, for a few specimens have been taken along arroyos in the desert plain. The white-throated wood rat is not closely restricted to the rock hill, for its nests are found widely scattered on the desert plain; yet it reaches its greatest abundance on rocky slopes.

This community was studied in the Tucson district by Harris and Dice and by Blossom on the Tucson Mountains, Tumamoc Hill, Black Mountain, Santa Catalina Mountains, and Tortollita Mountains.

Aerial association (Tucson district)

Mammals	Records
Macrotus californicus, leaf-nosed bat	1
Pipistrellus hesperus subspecies, canyon bat	5

We saw very few bats in the Tucson district and have therefore few records for the aerial association.

Edificarian association (Tucson district)

Mammals	Records
Macrotus californicus, leaf-nosed bat	77
Bassariscus astutus arizonensis, bassarisk	2
Spilogale species, spotted skunk	2
Peromyscus eremicus eremicus, cactus mouse	1
Neotoma albigula albigula, white-throated wood rat	4
Sylvilagus audubonii arizonæ, Arizona cottontail	1

We made no special effort to determine the mammals which inhabit houses or other buildings in the Tucson district and we have only a few records from the edificarian association (for definition see Dice, 1920, 24). Most of our records are from the Desert Laboratory main building.

Yuma Biotic District

The Yuma biotic district covers the low and very arid part of the Sonoran desert found in southwestern Arizona and northwestern Sonora. It extends from the Colorado River eastward to about Ajo and Gila Bend. It probably covers part of the low desert north of the Gila River, but we have no information about its boundaries in that region. It extends southwestward to the Gulf of California and for an unknown distance along the shores of that body of water. It includes the Pinacate Mountains and surrounding plain, but it is not known how far south into Sonora it extends. Very possibly the lower Magdalena Valley in Sonora, where the organ-pipe cactus, sahuaso, and other peculiar types of cacti occur, should be included in another biotic district.

The ecological associations of the Yuma district were not carefully studied by us and we shall make no attempt to describe them. Some ecological notes are given in an earlier section of this report under the descriptions of the principal collecting localities. Rock hill and desert plain communities are

known to occur, closely resembling some of the associations of the Tucson district.

Many of the small mammals of the southwestern Arizona deserts differ subspecifically from those of the Tucson district (see table 9). Some of the mammals of the riparian associations along the Colorado River (Grinnell, 1914, 101) differ subspecifically from those found farther east, and some of the species found along the river do not occur on the desert. However, we question the value of the riparian mammals for characterizing desert districts. The canyon mouse (*Peromyscus crinitus*) and the cactus wood rat (*Neotoma lepida*) occur in the desert mountains of the Yuma district, but neither has yet been reported from the Tucson district. From a sand-dune area at Puenta Peñascosa, on the northeast coast of the Gulf of California, Sonora, Huey (1934, 1–2) has described a very pale race (*Thomomys bottæ vanrossemi*) of the valley pocket gopher.

THE COLORS OF DESERT MAMMALS IN RELATION TO THE COLORS OF THE SOILS

That desert animals tend to be paler in color than animals from more humid regions has been noted by many observers. It has further been noted that the desert soils are also usually pale in color. The correlation between the pale colors of the desert animals and of the desert soils has been considered by Buxton (1923, 169–170) to be due to some unknown effect of the general physical environment of the desert, but most authors have considered the pale coloration of desert animals to be an adaptation for concealment from predators.

However, not all desert mammals are pale in color. In the deserts of southwestern North America occur many beds of dark-colored lava, and on these blackish rocks many of the rock-inhabiting species of mammals have developed local races which are exceptionally dark in color. In the more humid parts of North America, also, several dark-colored local races have developed on areas of dark-colored rocks. Among these may be mentioned a dark-colored ground squirrel (*Citellus spilosoma obsidianus*), a dark-colored pocket mouse (*Perognathus flavus fuliginosus*), and a dark-colored grasshopper mouse (*Onychomys leucogaster fuliginosus*) described by Merriam (1890, 56, 59, 74) from black lava beds in the San Francisco Mountain region of northern Arizona. Goldman (1918, 23–24) has described another dark-colored race of pocket mouse (*Perognathus apache cleomophila*) from black lava beds in the same region. Sumner and Swarth (1924, 98–103), however, have pointed out that these forms are not extraordinarily dark in pelage color, and Bradt (see Dice, 1933a, 292) states that these older lavas of the San Francisco Mountains region are much weathered and are generally less black in surface color than the Tularosa Malpais and other lava beds of New Mexico and Arizona.

A dark race of the Merriam kangaroo rat (*Dipodomys merriami vulcani*)

from near Vulcan's Throne, Mohave County, Arizona, has been described by Benson (1934, 181–184), who states that "the dark color of *vulcani* is probably correlated with the color of the volcanic cinders which cover the ground in the vicinity of Vulcan's Throne."

A subspecies of pika (*Ochotona princeps goldmani*) living on lava beds in the Snake River Desert, Idaho, is, according to A. H. Howell (1924, 40–41), the darkest member of the genus in North America. Another dark-colored subspecies (*O. p. nigrescens*) is found in the Jemez Mountains of New Mexico, where, according to Vernon Bailey (1931, 68), "their dark-gray color blends perfectly with the dark-gray lava slides in which they live, rendering them almost invisible to the naked eye as they sit on the rocks."

Mice of the genus *Peromyscus* living on lava beds are sometimes darker in color than those living on paler-colored rocks (Osgood, 1909, 16, 70, 144). Several species of wood rats also show tendencies toward dark pelage where they occur on dark-colored lavas (Goldman, 1910, 77, 81).

Pale races of mammals also occur in humid regions on soils which for one reason or another are unusually pale in color. Among other instances may be mentioned *Microtus breweri*, which is a pale-colored vole peculiar to the pale-colored sands of Muskeget Island, off the coast of Massachusetts (Bailey, 1900, 26). On the sands of Monomoy "Island," which is now connected with the mainland of Massachusetts, a slightly marked pale race of white-footed mouse (*Peromyscus leucopus ammodytes*) is found (Osgood, 1909, 121–122). On the pale-colored sands of the Florida beaches the old-field mouse (*Peromyscus polionotus*) has produced the pale-colored races *niveiventris*, *phasma*, *albifrons* (Osgood, 1909, 105–109), and *leucocephalus*. Sumner (1926, pls. 17, 18) has shown the striking correlation between soil color and pelage color in some races of these old-field mice. The exceedingly pale grasshopper mouse (*Onychomys leucogaster albescens*) found in a sand-dune area in northern Chihuahua (Hollister, 1914, 450–451) is perhaps another example of unusually pale pelage color associated with probably pale-colored soil. A local race of the deer mouse (*Peromyscus maniculatus*), paler than usual for the subspecies *Peromyscus maniculatus rubidus*, has been described by Sumner (1917, 173–185) from a small isolated sandy peninsula near Eureka, California. These examples show that pale-colored races of mammals are often produced on sandy areas even in regions of high humidity.

METHOD OF COLOR ANALYSIS

For the analysis of the colors of the desert mammals and of the surface soils of their habitats we have made tint photometer readings both of series of skins of many mammalian species and of samples of the surface soils.

The mammal skins were prepared in the field as filled-out specimens in the same manner as museum study skins are usually prepared. So far as possible the skins were made alike in makeup and in amount of filling used. After thorough drying the prepared study skins were degreased in several baths of Stoddard Solvent, a dry-cleaning solution, and it is believed that very little stain from the soil remains on the specimens.

The soil samples were collected from the surface of the ground at the collecting stations, an effort being made to secure an average sample of the surface rock fragments and finer material typical of the soil of the habitat.

The instrument used for the color determinations is the Ives tint photometer. A slight modification of the method used for the color determinations of flat skins (Dice, 1932b, 19) has been necessary. For these filled-out skins we have determined only the colors of the dorsal area, and of most of the specimens we have taken readings only for red, green, and blue-violet. As most of the skins have much the same general hue, it was not believed necessary to secure readings for the intermediate colors, yellow and peacock blue.

The tint photometer readings of these round skins are not directly comparable with readings of skins stretched flat under uniform tension, for the makeup of the round skins is much more variable. However, in this report all the readings have been taken from the filled-out skins and these are believed to be at least roughly comparable with one another.

In some of the samples of surface soil the various rock fragments are quite variable in color, and therefore are difficult to read with the tint photometer as ordinarily focused. For the soil samples we have therefore thrown the instrument out of focus, so as to secure a more uniform diffused color for the whole soil surface being studied. A number of readings were made of each soil sample, the sample being stirred up between succeeding sets of readings.

All the soil samples when read were in air-dry condition, which is the usual condition of the surface soils of the desert region. When moist, most of these soils, especially those containing any organic matter, would have appeared somewhat darker in color tone and therefore would have shown lower tint photometer readings than are here recorded.

The color readings for the specimens of *Perognathus intermedius*, *Peromyscus eremicus*, and *Neotoma albigula* were made by Blossom, who also made the readings for soil color for all the rock hill stations. Color readings of the specimens taken on types of habitat other than the rock hill have been made by Margaret Liebe and by Palmer Sime, who have also made the readings of the soil colors for these habitats. The statistical computations were made by Blossom and Margaret Liebe. The standard errors of the means, rather than the probable errors, have been used in all our computations.

SPECIES WHICH EXHIBIT GEOGRAPHIC COLOR VARIATIONS IN OUR AREA

A number of species of mammals which inhabit the southwestern arid regions vary in color from place to place. We shall therefore discuss briefly the color variations which have been noted in several species inhabiting the areas studied by us. The variations noted will be correlated so far as possible with environmental factors, particularly with the color of the soil, which seems to have an important relationship to the color of the pelage of the mammals.

Pipistrellus hesperus. Canyon bat. In southeastern Arizona the subspecies is *merriami*, which extends westward at least as far as the Santa Cruz River. In northwestern Sonora occurs the paler subspecies *hesperus*, of which we took only one specimen at Pitiquito.

Vulpes macrotis. Desert fox. The subspecies of desert fox (*Vulpes macrotis arizonensis*) of southwestern Arizona and adjacent Sonora is decidedly smaller and has much lighter dentition than the subspecies (*V. m. neomexicana*) found in New Mexico. Intergradation between the two subspecies is presumed to occur in southeastern Arizona (Goldman, 1931b, 249–250).

Citellus grammurus. From the black lava of the Tularosa Malpais a very dark-colored race of the rock squirrel (*Citellus grammurus tularosæ*) has been described by Benson (1932, 335–337 and pl. 3). Both the adults and young show the dark coloration. Benson points out that other dark-colored races of this species occurring in Texas, New Mexico, Nuevo Leon, and Tamaulipas may possibly be associated with areas of dark-colored rocks.

In southern Arizona the rock squirrel is chiefly an inhabitant of the montane and encinal belts in the higher mountains. A few occur on the lower desert, where it is most common on rocky slopes. It seems to be very rare or absent from most of the lower desert of southwestern Arizona.

Citellus spilosoma. The spotted spermophile has two color phases in southern Arizona, buff and gray (see Mearns, 1907, 333). The two specimens of the subspecies *canescens* which were secured at Hereford and at the eastern base of the Huachuca Mountains are both buff in color.

Ammospermophilus harrisii. The subspecies of antelope squirrel, *saxicola*, found on the lower desert plains of southwestern Arizona and northwestern Sonora is paler in color than the subspecies, *harrisii*, of the Tucson region, but the difference in color tone between the two subspecies is slight. The tint photometer readings for reflected red of 9 specimens of *saxicola* from southwestern Arizona and northwestern Sonora average 16.00 (13–20) per cent, while 12 specimens of *harrisii* from near Tucson average 14.42 (13–17) $\pm$ 0.45 per cent. On account of the small number of specimens available, the differences in color readings between the two subspecies are not of statistical significance.

Sciurus arizonensis. The several colonies of Arizona squirrels which occur on the upper parts of the Santa Catalina, Santa Rita, and Huachuca Mountains are isolated from one another by wide stretches of desert. On the Huachuca Mountains occurs a form, *huachuca*, with mostly grayish back and white under parts, while in northern Arizona the form *arizonensis* has a broad dorsal stripe of reddish brown along the whole back. The tree squirrels of the Santa Catalina and Santa Rita Mountains are more or less intermediate between these two subspecies, and according to Burt (1933, 117) there is considerable variability in specimens from the Santa Ritas. Burt assigns the Santa Rita series to *arizonensis*, while Doutt (1931, 271–273) has described the Santa Catalina form as a subspecies, *catalinæ*. On the Chíricahua Moun-

tains occurs the related species *chíricahuæ* (Goldman, 1933, 71–72), which has a grizzled back, while the thighs, forearms, and under parts are tawny.

Thomomys bottæ. Valley pocket gopher. The pocket gophers of the *bottæ* group are greatly variable in pelage color and to a lesser extent in body dimensions and skull characters. Many forms have been described from the western United States (see Goldman, 1935, 153–157) and from Mexico. In the area covered by this report the darkest form is *catalinæ*, which occurs in the humus-filled soils of the montane belt on the Santa Catalina Mountains. On the upper Chíricahua Mountains we secured another dark-colored race, *collinus*, but this form is not so dark as *catalinæ* (Goldman, 1931a, 420). A "small, rather dull buffy" subspecies, *extenuatus*, has been described by Goldman (1935, 149–150) from the Sulphur Springs Valley, which lies to the west of the Chíricahua Mountains, and its range extends west to the eastern base of the Huachuca Mountains. The moderately pale-colored subspecies *modicus* occurs on the desert plain near Tucson and at Continental, in the grassland belt in the Altar Valley near the Mexican boundary, near the lower edge of the oak belt on the western side of the Baboquivari Mountains, and on the desert plain at Pitiquito, Sonora. Some of the specimens in the Dickey Collection taken by A. B. Howell and L. M. Huey in the vicinity of Fort Lowell, Arizona, are much brighter in color than the rest of the specimens from the Santa Cruz Valley. Two of these specimens are near cinnamon of Ridgway in the color of the upper parts, rather than between army brown and buffy brown, as in most of the series. The rich ochraceous tawny subspecies, *pusillus*, is known only from a single specimen taken at an altitude of 3000 feet on the Coyote Mountains, in Pima County, Arizona, about 40 miles southwest of Tucson (Goldman, 1931a, 422). A pale-colored subspecies, *phasma*, is reported by Goldman (1933a, 72–74) and Grinnell and Hill (1936, 4) from a number of localities on the lower desert in southwestern Arizona and northwestern Sonora. A still paler subspecies, *vanrossemi*, has been described by Huey (1934, 1–2) from Punta Peñascosa, Gulf of California, Sonora. It is said to have been taken "on the land side of a series of large sand dunes that bordered the sea beach." From near the eastern base of the Tinajas Altas Mountains Grinnell and Hill (1936, 4) have described a small member of this group of pocket gophers under the name of *Thomomys perpallidus depauperatus.* Its pelage color is said to be similar to that of *phasma.*

Thomomys umbrinus. Encinal pocket gopher. The pocket gophers of the *umbrinus* group are represented in the upper parts of the Chíricahua, Huachuca, and Santa Rita mountains by dark-colored subspecies which have been named, respectively, *chiricahuæ* Nelson and Goldman (1934, 117), *intermedius* Mearns, and *burti* Huey (1932, 158–159). The moderately dark but richly colored subspecies *quercinus* Burt and Campbell (1934, 150–151) occurs in the oak belt of the Pajarito Mountains, just north of the Mexican boundary in southern Arizona. In our map we have included the Pajarito Mountains as a part of the Tumacacori Mountains. At the lower edge of the oak belt on the western side of the Santa Rita Mountains occurs the paler subspecies *proximus* Burt and Campbell (1934, 151).

No pocket gophers of the *umbrinus* group have been reported from the Sonoran desert. The common name "encinal pocket gopher" is here given to the group, referring to its common occurrence in the encinal belt.

Perognathus amplus. Two subspecies of the bahada pocket mouse occur in the area covered by our studies. On the sandy desert plains around Tucson is found the subspecies *taylori*, while on the lower more arid desert plains of southwestern Arizona and northwestern Sonora occurs the subspecies *rotundus*, which is much paler in color than *taylori* (Goldman, 1932, 489).

Perognathus apache. Apache pocket mouse. A very pale, nearly white race, *gypsi*, of the Apache pocket mouse occurs on the White Sands of the Tularosa Basin in southern New Mexico. A few mice of the same race occur also on the quartz sands immediately north of the White Sands (Benson, 1933, 26–30), but so far as is known none occur on other types of soil or in other habitats. The nearest relative is the yellowish buff subspecies *apache*, which inhabits suitable habitats in western New Mexico, eastern Arizona, and southern Utah.

No other mammal from our region has so pale a color as *gypsi*. There is considerable variability in color in the series of specimens from the White Sands, most of which are in the California Museum of Vertebrate Zoology. A few specimens approach the yellowish buff color of *apache*, but most of the *gypsi* are whitish in appearance.

The tint photometer readings for reflected red from the dorsal stripe of 63 specimens of *gypsi* average 35.95, with extremes of 26 and 49 (table 1). This is considerably less than the average for the gypsum soil of the White Sands, which has an average reading of 74.00 for reflected red. However, the sides and under parts of the mice are much lighter in color than the back, where many of the hairs have blackish tips. The sides and under parts of

TABLE 1—*Color of the Apache pocket mouse (Perognathus apache gypsi) and of desert soils: White Sands, near Alamogordo, New Mexico. Means, extremes, and standard errors of tint photometer readings.*
(Per cent)

	Red	Green	Blue-violet
Perognathus apache gypsi, 63 specimens, dorsal stripe	35.95 (26–49) ± 0.59	31.08 (19–44) ± 0.64	28.67 (15–40) ± 0.68
White Sands soil. .	74.00 (73–75)	63.60 (62–65)	55.80 (55–58)
Atriplex association soil	24.00 (23–25)	13.20 (12–14)	11.00 (10–12)

the mice are nearly pure white and appear even lighter in tone than the gypsum soil. We have, however, been unable to make satisfactory tint photometer readings of the sides or under parts of the prepared museum specimens.

Readings of the color of a sample of soil from *Atriplex* community (Dice, 1930, 10) is included in the table for comparison with the gypsum soil of the

White Sands. This soil sample was collected by Blossom immediately to the east of the White Sands. The soil here is a reddish buff in color and its mean tint photometer reading for reflected red is 24.00. The nearly white gypsum race of the Apache pocket mouse averages considerably paler even on its dark dorsal surface than the soil sample from the *Atriplex* community.

Perognathus baileyi. Bailey pocket mouse. This large pocket mouse is represented in our area by two races. Near Tucson and Oracle, the moderately pale-colored race *baileyi* occurs, while on the lower and more arid desert of southwestern Arizona and northwestern Sonora a race with paler-colored pelage, *domensis* (Goldman, 1928, 204), occurs.

Perognathus penicillatus. Wash pocket mouse. Throughout most of the Sonoran desert the wash pocket mouse has the normal desert type of pale coloration characterized by the subspecies *pricei.* Near Papago Tanks in the Pinacate Mountains, however, where the sands at the edge of the Pinacate lava are overlaid by a thin cover of black dust, two out of seven specimens of these mice are strikingly dark in color, the upper parts being a dull blackish buff. The other five specimens taken at this locality are colored the moderately pale dull buff typical of the subspecies *pricei.* At the base of Elegante Crater, where also the desert sand is overlaid by a layer of black dust, the one specimen of wash pocket mouse secured is dark in color, closely resembling the dark-colored specimens taken at Papago Tanks.

Perognathus intermedius. The rock pocket mouse is almost entirely restricted to the rock hill association, and therefore the sandy desert plains are nearly complete barriers to its distribution. It rarely occurs on rock-covered slopes and along rocky arroyos on the desert plains adjacent to its preferred rock hill habitat. That it must occasionally wander considerable distances on the desert plains is shown by the fact that almost every isolated desert butte and mountain is populated by the species. Such travels, however, need not be assumed to be successful more than once in a hundred or even a thousand years in order to explain the present distribution of the species.

Usually this small mouse is the most abundant mammal of rocky habitats on the Sonoran desert. Owing to the considerable number of specimens available for study, this species presents the best evidence among all the forms studied of the degree of correlation between mammalian pelage color and the color of the soil (table 2).

Males are more numerous than females in our series of the rock pocket mouse. However, no important differences in color between the sexes can be made out, and in our tables the two sexes have been combined. Nearly all our specimens are adult, but the young animals, except those very juvenile in character, seem to be colored like the adults. There seems to be some fading of pelage color in late summer, but we have few specimens from that season, and at other seasons the colors show no important seasonal variation. A few obviously faded, juvenile, and defective specimens have been omitted from the averages. We believe that our several series of specimens from the

various localities are comparable as to color and that the differences which appear between the several series are due to differences in the constitution of the stocks at those localities and not to differences in season of collection.

The palest-colored of the described races of the rock pocket mouse is *phasma,* which lives on the pale granites and gneisses of the Tinajas Altas Mountains, but which also occurs on the black lava of the adjacent Raven Butte. On light-colored rocks throughout this whole region, from the Gila Mountains of Yuma County, Arizona, to the Sacramento Mountains of New Mexico, occur moderately pale-colored mice of this species. There is considerable variation in pelage color from place to place, part of which is correlated with differences in rock color on the several mountains, but all the moderately pale stocks are here referred to the subspecies *intermedius.*

On black lavas several blackish races have developed. The black Pinacate lava is inhabited by the dull blackish race *pinacate;* on Black Mountain and on Tumamoc Hill near Tucson occurs the dark-colored form *nigrimontis;* the Kenzin lavas in southern New Mexico have another dark-colored race, *rupestris;* while the black lava of the Tularosa Malpais has the blackest race of all, *ater.*

In table 2 are given the tint photometer readings for the pelage on the mid-dorsal area of the prepared skins of these mice. Every desert locality has been included from which a series numbering four or more specimens is available. Two series of readings are given for the mice from the Tularosa Malpais, one series being made up of specimens prepared in the field, the other of specimens prepared from animals which were kept for a number of months in the laboratory before being killed. In the same table are given the tint photometer readings for samples of the surface rocks and soil from the same stations.

It will be noted from the table and also from figure 5 that in pelage color the stocks of pocket mice fall into two main groups. One group, composed of the stocks from the Tularosa Malpais, the Kenzin lava, three localities on the Pinacate lava, Black Mountain, and Tumamoc Hill, all have very dark-colored pelage. All these habitats are characterized by very dark-colored igneous rocks. The other group includes mice with much lighter pelage colors and comprises the remaining stocks.

The series from Tinajas Altas and from Raven Butte are much lighter than all the others. Tinajas Altas is located at the southern end of a mountain ridge made up mostly of very light-colored granites, and the correlation between light-colored pocket mice and light-colored rocks agrees with our general thesis. Raven Butte, on the contrary, is made up of very dark-colored lava rock, yet the mice found here average slightly paler in pelage than those of the Tinajas Altas Mountains. The explanation is obvious, we think, for Raven Butte is directly connected with the Tinajas Altas Mountains, of which it forms but a small part, and the rocky habitat is continuous between the butte and the mountains. It would not be expected that in the absence of a barrier to distribution a dark-colored race of the pocket mice could develop on Raven Butte.

TABLE 2—*Dorsal pelage color of the rock pocket mouse (Perognathus intermedius) compared with soil color. Mean tint photometer readings and their standard errors, arranged in order of magnitude of the readings for red of the pelage.*

(Per cent)

Stock	No. of specimens	Dorsal pelage color (means and standard errors)			Soil of habitat (means and extremes)		
		Red	Green	Blue-violet	Red	Green	Blue-violet
Tularosa Malpais (prepared in field)	14	6.29 ± 0.12	5.07 ± 0.07	4.36 ± 0.13	10.33 (5–13)	7.56 (4–10)	6.67 (3–9)
Tularosa Malpais (kept in laboratory)	11	7.00 ± 0.25	5.64 ± 0.30	5.18 ± 0.21	10.33 (5–13)	7.56 (4–10)	6.67 (3–9)
Kenzin lava	21	9.38 ± 0.33	7.43 ± 0.28	6.09 ± 0.24	11.37 (8–13)	9.21 (7–11)	8.26 (6–10)
Pinacate lava in Arizona	23	9.70 ± 0.30	7.65 ± 0.30	6.91 ± 0.25	13.25 (10–20)	9.70 (6–14)	9.10 (5–13)
Papago Tanks	23	10.70 ± 0.27	8.26 ± 0.27	7.17 ± 0.27	16.71 (10–20)	12.75 (6–17)	12.21 (6–17)
Elegante Crater	16	10.81 ± 0.37	8.31 ± 0.31	7.00 ± 0.31	11.04 (8–15)	9.14 (7–13)	8.73 (6–12)
Black Mountain	46	11.63 ± 0.33	7.81 ± 0.22	6.47 ± 0.16	10.63 (8–16)	8.77 (6–14)	7.87 (5–13)
Tumamoc Hill	39	12.53 ± 0.30	9.06 ± 0.19	7.55 ± 0.15	15.75 (8–25)	10.43 (5–18)	8.61 (5–16)
Wellton Hills	4	17.75 ± 0.74	13.00 ± 0.93	11.25 ± 0.82	18.40 (12–26)	14.36 (10–20)	13.04 (8–20)
Tule Tank	8	17.87 ± 1.07	12.50 ± 0.73	9.87 ± 0.76	43.65 (35–48)	38.15 (30–43)	36.10 (29–42)
Agua Dulce Mountains	14	18.36 ± 0.56	13.21 ± 0.43	11.07 ± 0.40	23.09 (18–30)	15.71 (12–20)	13.81 (10–18)
Pima Canyon	12	19.00 ± 0.52	12.79 ± 0.50	10.67 ± 0.52	36.53 (11–56)	28.93 (9–50)	25.40 (9–46)
Cabeza Prieta Mountains	4	19.25 ± 0.42	13.25 ± 0.22	11.25 ± 0.22	43.44 (37–51)	36.68 (30–45)	33.52 (27–41)
Crow Butte	28	19.25 ± 0.49	13.43 ± 0.42	11.14 ± 0.36	13.39 (11–15)	10.67 (9–14)	10.05 (8–12)
Tortollita Mountains	24	19.58 ± 0.89	13.60 ± 0.24	10.98 ± 0.22	43.04 (32–49)	34.58 (26–40)	30.12 (21–36)
Telegraph Pass	20	20.20 ± 0.73	15.20 ± 0.67	12.95 ± 0.58	19.80 (15–25)	13.64 (9–18)	11.76 (8–15)
Tinajas Altas	17	23.53 ± 0.71	17.41 ± 0.58	14.41 ± 0.52	43.33 (31–52)	37.37 (26–47)	34.77 (23–45)
Raven Butte	11	24.54 ± 0.80	18.82 ± 0.92	15.82 ± 0.92	14.35 (10–20)	10.78 (7–15)	9.70 (7–13)

On Crow Butte the rock pocket mice are similar in color to those living on the adjacent Cabeza Prieta Mountains. The butte of black lava is separated from the mountains by only about ¼ mile of desert sands, and the mice are probably able to cross this plain from time to time. The mice from Crow Butte and the Cabeza Prieta Mountains are darker in color (see table 2) than those from the Tinajas Altas Mountains and Raven Butte, and they have been assigned to the subspecies *intermedius* rather than to *phasma*. Those from Crow Butte are, moreover, much more variable in color than our series of *phasma*, and some individuals are nearly as dark as the lava rocks on which they live. In the Cabeza Prieta Mountains and in the nearby Tule Mountains there are numerous caps of black lava, so that the mountains are made up in part of very pale granites and gneisses and in part of black lava. The intermediate color tone of the pocket mice from these mountains and from Crow Butte is probably a response to this mixture of color tones in their geographical habitat.

The pelage color of these mice shows in general a striking correlation with the color of the rocks of the particular mountain where they live. This correlation is best shown statistically by the rank correlation coefficient. The coefficient has been calculated by Margaret Liebe from the serial order of magnitude of the tint photometer readings for reflected red in the dorsal pelage of the rock pocket mice as compared with the serial order of similar readings for samples of the surface rock taken at the same stations. The coefficient is 0.807, which is considered to represent a high degree of correlation.

There is presented in figure 5 a comparison of the color of the dorsal surface of the several series of specimens of rock pocket mice which are available from our area. The graphs show the tint photometer readings for reflected red in the dorsal pelage, and the stocks have been arranged in order of ascending values for the readings.

The graphs are prepared in the manner worked out by Dice and Leraas (1936). The length of the line for each stock represents the extreme variation for readings of red dorsal color in the series. The crossbar near the middle of the line indicates the mean of the series, and other crossbars are placed 2 times the standard error (= 3 times the probable error) of the mean above and below the mean, forming a rectangle. In comparing any two series of measurements, if the two rectangles formed about the respective means do not overlap, then the two series of measurements usually will differ by a statistically significant amount. For instance, in the figure, the stock from Tinajas Altas apparently differs significantly from the stock from Telegraph Pass, but not from the stock from Raven Butte.

In figure 6 are presented graphs of the means and extremes of the tint photometer readings for surface rock color at the same stations represented for pelage color of pocket mice in figure 5. From the graphs it is apparent that there is much more variability in rock color than in pelage color at most of the stations. The stocks living on black lavas, except on Raven Butte

FIG. 5—Graph of dorsal pelage color of the rock pocket mouse (*Perognathus intermedius*) from various stations in southwestern North America. For each station are given, in percentages, the means, 2 times the standard error on each side of the means, and the extremes of the tint photometer readings for reflected red of museum specimens.

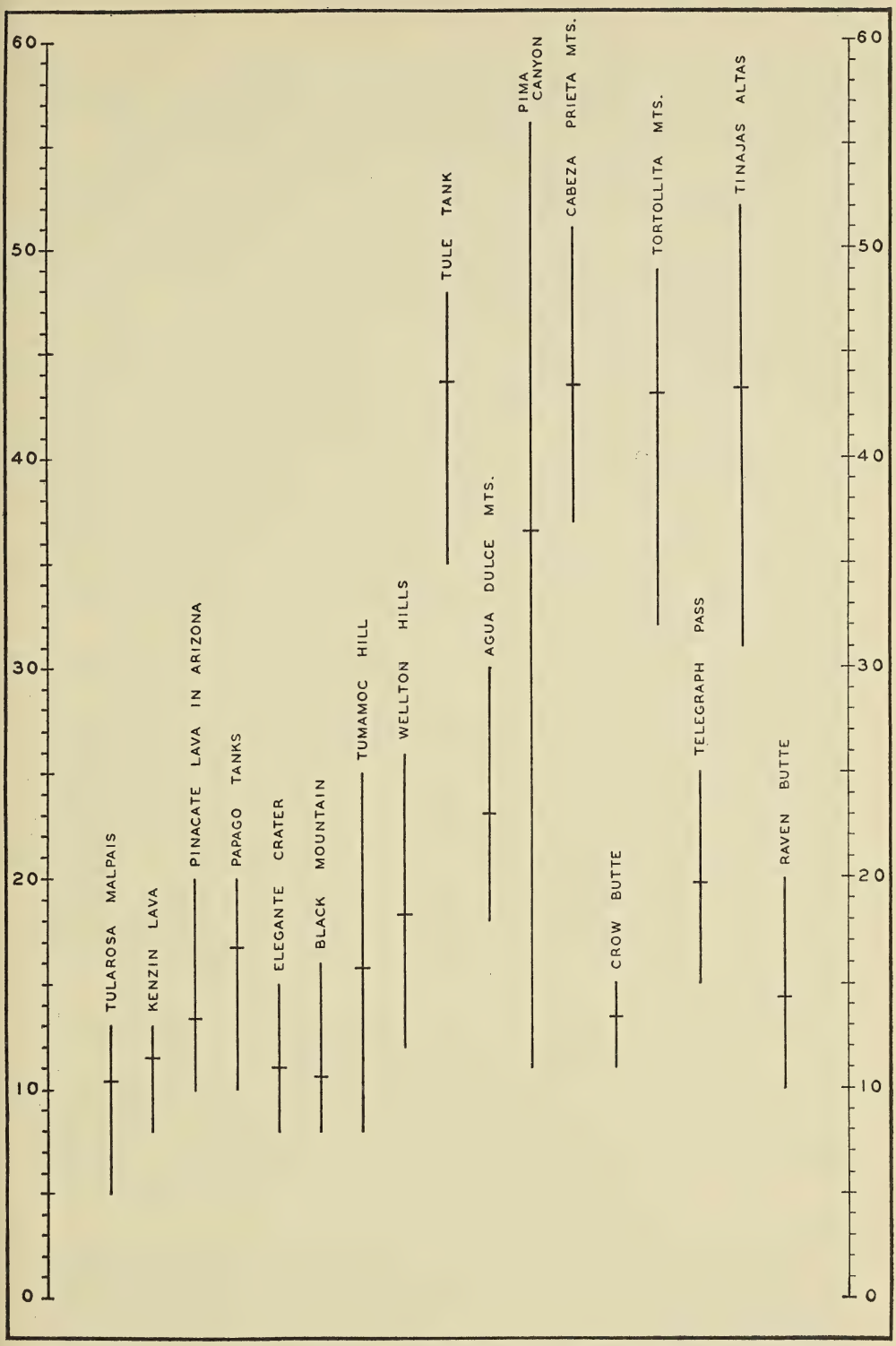

FIG. 6—Graph of colors of surface rocks at various stations in southwestern North America. Means and extremes of tint photometer readings for reflected red of soil samples, in percentages; arranged in the same order as the corresponding series of specimens of pocket mice in figure 5.

and Crow Butte, where adjacent pale-colored rocks exert an influence, are in general of shades closely similar to those of the rocks on which they live. On the Tularosa Malpais, Kenzin lava, Tumamoc Hill, and on the three stations on the Pinacate lava, the dorsal surfaces of the mice of each station average darker than the soil colors, as shown by lower average tint photometer readings. On Black Mountain, on the contrary, the pelage color of the upper side of the mice averages paler than that of the rocks. None of the differences in average color between pelages and soils at the same station are as great as 4.0 tint photometer readings.

On the lighter-colored soils the difference between the color of the mice and of the soils is in general great. Only on the Gila Mountains and Wellton Hills are the dorsal pelage colors close in average tint photometer readings to the average color of the rocks. The Agua Dulce mice average on their dorsal surface 4.73 tint photometer readings darker for reflected red than the rocks from the same station. The mice from Pima Canyon, Tortollita Mountains, Tule Tank, Cabeza Prieta Mountains, and Tinajas Altas are all considerably darker in average color tone on their upper surface than the rocks on which they live. All these mice are, however, much lighter in color on their sides and under parts than on their mid-dorsal line, at which place the tint photometer readings were made.

Three series of specimens, from the Agua Dulce Mountains, from north of the Santa Catalina Mountains near Oracle, and from near Highrolls in the Sacramento Mountains of New Mexico, are more reddish buff in hue than the other series of these mice. All these series are made up of few specimens, and only the Agua Dulce series is given in the table, where the tendency toward a reddish buff hue is not brought out by the tint photometer readings. The soil color in all three of these situations is distinctly reddish in general tone, and the indication is that the hue of the pelage of these mice tends to resemble the hue of the rocks where they live. If this is true, there is a tendency in these mice toward correlation between pelage color and soil color not only in shade or tint but also in hue. However, our data bearing on this point are very meager.

It seems likely that the genetic basis of the black color is different in the several dark-colored subspecies of rock pocket mice, *nigrimontis*, *ater*, *rupestris*, and *pinacate*. In *nigrimontis* and to a lesser degree in *rupestris* the specimens form a more or less completely graded series of increasing blackness, and under the usual genetic interpretation the blackish color would be considered to be produced by multiple factors. The pale color of *phasma* may be due to a dilution factor or factors, for on the paler specimens the pigment at the bases of the hairs is very pale.

On the other hand, in *ater* the mice are quite uniform in black color, and the hairs lack the agouti pattern. In character these mice somewhat resemble superficially the melanistic varieties found in house mice, rats, guinea pigs, rabbits, and other domestic animals in which the black color has been found to be due to a single Mendelian factor difference from the normal agouti color.

On the Tularosa Malpais, where most of the population is black in color, several specimens of gray agouti color have been taken, but no specimens intermediate between gray and black. In *pinacate*, also, the series of specimens from the Pinacate lava shows relatively little variability in shade of color, though on the Pinacate lava in Arizona one gray agouti pocket mouse was taken at a station where all the other mice of this species were of typical *pinacate* blackish color.

There is a suggestion, then, that the genetic differences between the blackish colors of *ater* and of *pinacate* and the more usual gray agouti color of the species are each due mainly to single factor differences, while the blackish colors of *rupestris* and *nigrimontis* are due to multiple factors. It is not suggested that the blackish colors of *ater* and *pinacate* are due to the same factor for black, for *pinacate* has a paler, more slaty color than *ater*. However, it is possible that a modifying factor or factors for black might be involved here. We have failed to get these animals to breed in captivity, and the mode of inheritance of these color characters cannot be tested.

Dipodomys spectabilis. Banner-tailed kangaroo rat. In southeastern Arizona the subspecies *spectabilis* occurs, while in the region around Tucson, including Oracle and west to the Baboquivari Mountains and Indian Oasis, there occurs the subspecies *perblandus*, a smaller and paler form (Goldman, 1933, 466). We have no records for the species in extreme southwestern Arizona.

Dipodomys merriami. Merriam kangaroo rat. The race *merriami* of southeastern Arizona is a medium gray buff in color. It is replaced in southwestern Arizona and northwestern Sonora by another race, *simiolus*, which is colored a pale yellow buff. The tint photometer readings of seven specimens of *simiolus* from the Pinacate Mountains and from Pitiquito, Sonora, are compared in table 3 with a series of fifteen specimens of *merriami* from near Tucson. The number of specimens of *simiolus* is too small to justify the calculation of the standard error, but the differences in color between the two subspecies probably are statistically significant. For each color screen *simiolus* has higher average readings, indicating paler color tones.

TABLE 3—*Dorsal pelage color of the kangaroo rat (Dipodomys merriami). Means, extremes, and standard errors of tint photometer readings.*
(Per cent)

Subspecies	No.	Red	Green	Blue-violet
Merriami	15	13.60 (10–17) ± 0.48	9.93 (7–13) ± 0.44	8.13 (6–10) ± 0.40
Simiolus	7	18.14 (14–24)	12.57 (10–17)	10.14 (8–14)

Onychomys torridus. Scorpion mouse. In southern New Mexico and southeastern Arizona occurs the subspecies *torridus*, while southwestern Arizona is occupied by the paler subspecies *perpallidus* (Hollister, 1914, 459).

Peromyscus eremicus. Cactus mouse. The usual color of the cactus mouse in southern Arizona and southern New Mexico is pale gray with a tinge of

buff. These forms are assigned to the subspecies *eremicus*. On Black Mountain near Tucson the cactus mice tend toward a dull blackish gray in pelage color, and have been described by Blossom (1933a, 1–3) as a distinct subspecies, *pullus*. On the Pinacate lava another dark form occurs, but this has more buff in the pelage than *pullus*. It has been described by Goldman (1917, 110–111) as *papagensis*.

Benson (1933, 38–42) has pointed out that there is considerable variability in pelage color in the cactus mouse in southern New Mexico, and that some dark-colored individuals occur in the populations on the Tularosa Malpais and on the Kenzin lava. He states (p. 40) that "the series of fifteen specimens from the lava bed near Kenzin display a range of variation which is about equal to the total amount of geographical variation in all the races of *Peromyscus eremicus*, yet no two specimens are exactly alike in color."

Laboratory studies of the variability in this species are being conducted at the University of Michigan, and a critical discussion of color variation in this species must be deferred until the laboratory study is completed.

The greater variability of *Peromyscus eremicus* as compared with *Perognathus intermedius* at the same localities is probably correlated in part with the less complete restriction of the *Peromyscus* to rocky habitats. Near Robles Ranch Dice found the cactus mouse far out on the desert plain. With incomplete restriction of the *Peromyscus* colonies to the various desert mountains, the tendency toward the production of a local race on each mountain is counteracted by interbreeding across the connecting desert plains.

Peromyscus maniculatus. Deer mouse. In the Sonoran desert the deer mouse is reported only from the cottonwood–willow association along the Santa Cruz River at Continental. It is rare also on the grassland belts of southeastern Arizona. It is common in the forest belts of the upper parts of the Santa Catalina and Chíricahua Mountains, and undoubtedly occurs also in the upper parts of the other forested mountains of the region.

The type locality of the subspecies *sonoriensis* is Santa Cruz, on the Santa Cruz River, Sonora, about 7 miles south of the Arizona line. We did not trap at the type locality, and our nearest collecting station is at the mouth of Miller Canyon, on the eastern side of the Huachuca Mountains. The series from Miller Canyon is dull light gray in average color tone. On the grassland belt north of the Santa Catalina Mountains near Oracle the species is rare and only four individuals were secured. These were of an average bright yellow buff in color, much clearer in color tone than the series from Miller Canyon. They are here assigned to *sonoriensis*. A series from Rustler Park and Rock Creek Canyon in the upper part of the Chíricahua Mountains are dark yellow buff in color, much darker than the *sonoriensis* from near Oracle. Osgood (1909, 74) assigns specimens from the Chíricahua Mountains to *rufinus*, and our series is therefore assigned to that subspecies.

In the highest and most heavily forested part of the Santa Catalina Mountains, on the northern slopes of Mount Lemmon, at elevations of 8000 feet and above, the deer mice are very dark in color, a blackish buff, very dif-

ferent from the other series here mentioned. The mean tint photometer reading for reflected red in this series is only 6.86 (table 4). They are, however, also referred to the subspecies *rufinus*. In open forest of yellow pine type in these mountains at Summerhaven, elevation about 7500 feet, the mice of this species are distinctly paler in color, and may be assumed to be intergrading toward *sonoriensis*.

In the desert areas of New Mexico and extending westward to the eastern base of the Chíricahua Mountains occurs the subspecies *blandus*, which is represented by two color phases, buff and gray. It has been shown by one of us (Dice, 1933c, 571–574) that in heredity the gray color phase is a single-unit recessive to buff, but there are some modifying factors.

TABLE 4—*Dorsal pelage color of the deer mouse (Peromyscus maniculatus). Means and extremes of tint photometer readings.*
(Per cent)

Subspecies and station	No.	Red	Green	Blue-violet
Rufinus:				
Mount Lemmon	7	6.86 (6–7)	5.29 (5–6)	4.43 (4–5)
Summerhaven	4	7.75 (6–10)	5.75 (5–7)	4.75 (4–6)
Rustler Park	9	10.11 (8–14)	7.11 (6–9)	5.67 (4–8)
Sonoriensis:				
Mouth of Miller Canyon	1	13.00	9.00	7.00
Oracle	1	16.00	9.00	7.00

Peromyscus truei group. Pinyon mouse and allies. In southeastern Arizona we have records for the pinyon mouse (*Peromyscus truei truei*) only for Rock Creek Canyon in the Chíricahua Mountains. Cahalane (unpublished manuscript) secured the long-nosed mouse (*Peromyscus nasutus nasutus*) from the upper parts of the Chíricahua Mountains. Osgood (1909, 30) considers *nasutus* to belong to the *truei* group, and in this view we concur. On the Chíricahua Mountains both *truei* and *nasutus* are of the usual pale buff coloration.

From the Tularosa Malpais Benson (1932, 338–339) has described a blackish race of the long-nosed mouse (*Peromyscus nasutus griseus*). Bradt (1932, 326) took both the blackish *griseus* and typical pale buff *truei* here together in the same trap line.

Sigmodon hispidus. Hispid cotton rat. In southeastern Arizona suitable habitats for the hispid cotton rat are few and widely scattered, and the species is accordingly local in distribution and usually rare. Relatively few specimens are available from the region and many of these are immature individuals which do not fully represent the characters of the races.

Specimens from riparian habitats near Tucson and from a grassy spot on Tumamoc Hill are dark in color and are referred to the subspecies *cienegæ*, as are also specimens from along the San Pedro River near Hereford. Specimens from the Huachuca Mountains are paler in color than typical *cienegæ* and have yellowish noses and eye rings. A specimen of similar character has been reported by Hall (1934, 54) from the Animas Valley, New Mexico.

Neotoma albigula. White-throated wood rat. This species of wood rat is most abundant in the rock hill association, but is not so closely limited to this habitat as are the rock pocket mouse and cactus mouse. Nevertheless, several color races have been described from isolated desert mountains and lava beds, and the pelage color of some of these races is closely correlated with the color of the rocks on which the animals live.

On the pale-colored granites and gneisses of the Tinajas Altas Mountains occurs the pale-colored race *mearnsi.* The same form was taken on the black lava of the adjacent Raven Butte. On the Pinacate lava in Sonora occurs the dark-colored form *sheldoni.* The specimens on hand of this race are not so dark as are the specimens of the Pinacate race of rock pocket mouse, *Perognathus intermedius pinacate,* and are much more variable in shade of color. On the other hand, a single specimen of this species taken on the Pinacate lava plain in Arizona is not dark in color, but is here assigned to the pale-colored subspecies *mearnsi.* It closely resembles a specimen taken at the base of the Agua Dulce Mountains, which is also assigned to *mearnsi.* These two specimens are, however, somewhat darker in color than is typical of the subspecies on the Tinajas Altas Mountains. On the black lava of the Tularosa Malpais occurs a very dark-colored form, *melas,* almost black, and quite constant in shade, as shown by the tint photometer readings (table 5).

The subspecies *albigula,* to which are referred the specimens from most parts of southern New Mexico and Arizona, is rather pale gray in color, but there is considerable variability within the series. Of four individuals taken on Black Mountain, near Tucson, two, only one of which is preserved, are very dark in pelage color, though not so dark as *melas.* The one preserved individual is of a different color tone from *sheldoni.* Its tint photometer reading for red is 9. The other two specimens from Black Mountain, and two others taken on the adjacent desert plain, are of the usual gray color. Perhaps a dark-colored race is in process of formation on this mountain, though interbreeding with the surrounding population of gray animals may cause it always to be greatly variable. Another dark-colored individual occurs in a series of nine specimens taken by Blossom on the northeastern slopes of the Tucson Mountains, 4 miles west of Tucson. This individual is less dark than the specimen from Black Mountain, and is of a somewhat different hue.

In table 5 are given the average and extreme tint photometer readings for the dorsal pelage of the specimens at hand of the several races of the white-throated wood rat from southern Arizona, southern New Mexico, and northwestern Sonora. For each subspecies are given the tint photometer readings of the soil color for one station in the range of the subspecies. The station selected is that one which seems to have a soil color most characteristic of the habitat of the subspecies. The soil colors of additional rock hill stations may be found in table 2.

It is obvious from table 5 that there is nearly as much variation in color

in the white-throated wood rat as in the rock pocket mouse, and that the colors of the two species parallel each other as well as the rock colors in a remarkable manner. However, the local populations of the wood rat are more variable than are the local races of the rock pocket mouse. This greater variability we assume to be due in part at least to the lesser restriction of the wood rats to the rock hill habitat, and a consequent lesser degree of isolation on the several desert mountains.

Neotoma mexicana. Mexican wood rat. Specimens of *bullata* from the Santa Catalina Mountains are slightly darker and more reddish buffy than those of *mexicana* from the Chíricahua Mountains. There are also slight differences in skull characters between these races.

TABLE 5—*Dorsal pelage color of the white-throated wood rat (Neotoma albigula) compared with soil color. Means and extremes of tint photometer readings.*
(Per cent)

Subspecies and station	No.	Red	Green	Blue-violet
Mearnsi	3	20.70 (18–24)	18.30 (17–20)	15.00 (13–17)
Tinajas Altas soil	..	43.33 (31–52)	37.37 (26–47)	34.77 (23–45)
Albigula (Tucson region)	24	12.83 (9–17)	10.54 (7–13)	8.83 (6–11)
Pima Canyon soil	..	36.53 (11–56)	28.93 (9–50)	25.40 (9–46)
Sheldoni	5	10.40 (9–11)	8.60 (8–9)	6.80 (5–8)
Papago Tanks soil	..	16.71 (10–20)	12.75 (6–17)	12.21 (6–17)
Ater	3	4.20 (4.0–4.5)	3.00 (3–3)	2.70 (2.5–3.0)
Tularosa Malpais soil	..	10.33 (5–13)	7.56 (4–10)	6.67 (3–9)

TABLE 6—*Dorsal pelage color of the cactus wood rat (Neotoma lepida) compared with soil color. Means and extremes of tint photometer readings.*
(Per cent)

Subspecies and station	No.	Red	Green	Blue-violet
Auripila	5	17.60 (13–23)	13.80 (11–18)	10.80 (8–14)
Agua Dulce Mountains soil	...	23.09 (18–30)	15.71 (12–20)	13.81 (10–18)
Bensoni	2	7.00 (6–8)	5.50 (5–6)	4.50 (4–5)
Papago Tanks soil	...	16.71 (10–20)	12.75 (6–17)	12.21 (6–17)

Neotoma lepida. Cactus wood rat. Several races of the wood rats of the *lepida* group occur in southwestern Arizona and northwestern Sonora. The pale-colored subspecies *flava* is confined, so far as is known, to the light-colored rocks of the Tinajas Altas Mountains (Benson, 1935, 8). The rich pinkish buff subspecies *auripila* lives in the Agua Dulce Mountains, in a general area of reddish rocks, though one specimen has been taken on Crow Butte, a small hill of blackish lava at the western border of the Cabeza Prieta Mountains. On the black Pinacate lava lives the nearly black subspecies *bensoni.* In western Arizona, beyond our limits, another subspecies, *devia,* occurs, the upper parts of which are grayish buff in general color tone (Goldman, 1927, 206).

In table 6 it will be noted that the tint photometer readings for the dark-colored race *bensoni* are much lower than those for the golden buff race *auripila*. The darkest *auripila* is much paler than the palest specimen of *bensoni*. Our series are small, however, and with larger series the gap in color tone between the two subspecies may be bridged.

We do not have at hand specimens of the subspecies *flava* and we are therefore unable to give tint photometer readings of the pelage of this pinkish buff race.

CORRELATION BETWEEN PELAGE COLOR AND LIFE BELT

Most of the mammals living on the desert plains of southwestern North America are pale in color, as previous authors have noted of desert animals in every continent. In contrast, many of the mammals living in the forests of the upper parts of the Santa Catalina Mountains are dark in color, resembling in shade of color the mammals of forested sections of other parts of the continent. It has seemed desirable, therefore, to determine the amount of correlation between mammalian pelage color and life belt in the region most intensively studied by us. The vicinity of Tucson is an especially good place for such a comparison, for here the life belts are strikingly distinct.

Counter shading occurs on nearly all the mammals of Arizona. In all our species of mammals except the skunks, so far as we can determine, the under parts are lighter in color than the upper parts. In many of the small rodents the under parts are white or nearly so, and the pale ventral color often meets the darker color of the side in a sharp line.

The occurrence of counter shading is not correlated in any way with life belt, and in the following discussion of pelage color we have confined our attention for the most part to the dorsal surface of the specimens. From the viewpoints of most predators the under surfaces of the animals are generally out of view. Furthermore, we have found it difficult to obtain tint photometer readings for any surface of the specimens other than the dorsal side.

Color pattern may be concealing against a broken background of twigs, leaves, or rocks, as has been pointed out by Thayer (1909). Small mammals of southeastern Arizona which are marked with a pattern on their upper parts are the round-tailed spermophile, antelope squirrel, rock squirrel, chipmunk, Arizona squirrel, and the kangaroo rats. Of the larger species, the skunks, badger, bassarisk, raccoon, bobcat, and bighorn have more or less distinct streaks or spots. The deer and cougar are spotted when young. Species with patterns occur in every life belt and there seems to be no important difference in the prevalence of streaked or spotted patterns between the mammals of the montane forests and those of the desert plain.

The dorsal colors of most of the more abundant species of small mammals of the Tucson region are compared in table 7. In the table the tint photometer readings of the several subspecies are grouped according to the life belts

TABLE 7—*Dorsal pelage color of mammals from various life belts in southeastern Arizona. Means, extremes, and standard errors of tint photometer readings of dorsal area of filled-out museum skins.*

(Per cent)

Life belt and species	No.	Red	Green	Blue-violet
Montane forest, Santa Catalina Mountains:				
Myotis volans interior	2	7.50 (7–8)	5.00 (5–5)	4.00 (4–4)
Eptesicus fuscus pallidus	2	7.50 (7–8)	5.50 (4–7)	4.00 (3–5)
Thomomys bottæ catalinæ	4	5.00 (3–6)	3.50 (2–5)	3.25 (2–4)
Peromyscus maniculatus rufinus (Mt. Lemmon only)	7	6.86 (6–7)	5.29 (5–6)	4.43 (4–5)
Peromyscus maniculatus rufinus (Summerhaven only)	4	7.75 (6–10)	5.75 (5–7)	4.75 (4–6)
Peromyscus boylii rowleyi	16	11.06 (7–13) ± 0.41	8.87 (6–11) ± 0.38	7.25 (5–10) ± 0.40
Neotoma mexicana mexicana	5	10.80 (8–16)	8.60 (7–12)	7.20 (6–10)
Encinal, Santa Catalina Mountains:				
Eptesicus fuscus pallidus	2	7.50 (7–8)	5.50 (4–7)	4.00 (3–5)
Perognathus baileyi baileyi	41	16.02 (11–22) ± 0.39	10.80 (7–16) ± 0.28	8.71 (5–13) ± 0.26
Peromyscus eremicus eremicus	29	12.93 (8–19)	10.65 (6–16)	8.72 (5–12)
Peromyscus boylii rowleyi	16	11.06 (7–13) ± 0.41	8.87 (6–11) ± 0.38	7.25 (5–10) ± 0.40
Neotoma albigula albigula	24	12.83 (9–17) ± 0.41	10.54 (7–13) ± 0.34	8.83 (6–11) ± 0.26
Grassland, near Oracle:				
Ammospermophilus harrisii harrisii	12	14.42 (13–17) ± 0.45	12.50 (11–15) ± 0.36	10.33 (9–12) ± 0.34
Perognathus amplus taylori	8	25.12 (21–30)	17.75 (15–20)	12.37 (9–15)
Perognathus baileyi baileyi	41	16.02 (11–22) ± 0.39	10.80 (7–16) ± 0.28	8.71 (5–13) ± 0.26
Dipodomys ordii ordii	2	11.50 (11–12)	9.00 (8–10)	7.50 (7–8)
Dipodomys merriami merriami	15	13.60 (10–17) ± 0.48	9.93 (7–13) ± 0.44	8.13 (6–10) ± 0.40
Onychomys torridus torridus	13	14.85 (12–19) ± 0.60	10.08 (7–12) ± 0.41	8.31 (5–11) ± 0.49
Reithrodontomys megalotis megalotis	5	12.00 (10–15)	8.40 (7–10)	6.40 (6–7)
Peromyscus maniculatus sonoriensis (Oracle only)	1	16.00	9.00	7.00
Neotoma albigula albigula	24	12.83 (9–17) ± 0.41	10.54 (7–13) ± 0.34	8.83 (6–11) ± 0.26
Tucson desert plain:				
Citellus tereticaudus neglectus	30	19.03 (15–24) ± 0.35	14.40 (11–20) ± 0.31	11.47 (9–16) ± 0.26
Ammospermophilus harrisii harrisii	12	14.42 (13–17) ± 0.45	12.50 (11–15) ± 0.36	10.33 (9–12) ± 0.34
Perognathus amplus taylori	8	25.12 (21–30)	17.75 (15–20)	12.37 (9–15)
Perognathus baileyi baileyi	41	16.02 (11–22) ± 0.39	10.80 (7–16) ± 0.28	8.71 (5–13) ± 0.26
Perognathus penicillatus pricei	28	17.04 (13–21) ± 0.35	10.71 (8–13) ± 0.22	8.57 (6–10) ± 0.22
Dipodomys merriami merriami	15	13.60 (10–17) ± 0.48	9.93 (7–13) ± 0.44	8.13 (6–10) ± 0.40
Onychomys torridus torridus	13	14.85 (12–19) ± 0.60	10.08 (7–12) ± 0.41	8.31 (5–11) ± 0.49
Peromyscus eremicus eremicus	29	12.93 (8–19)	10.65 (6–16)	8.72 (5–12)
Neotoma albigula albigula	24	12.83 (9–17) ± 0.41	10.54 (7–13) ± 0.34	8.83 (6–11) ± 0.26

in which they occur. However, the means given for each subspecies are made up from readings from all the specimens which we have on hand from southeastern Arizona, regardless of the life belt in which each particular specimen was taken. If a subspecies occurs in two belts, identical readings are given for the two belts. Only for the specimens of the deer mouse (*Peromyscus maniculatus rufinus*) from the Santa Catalina Mountains has the series been subdivided. There are notable differences between the color of the series from Mount Lemmon, elevation 8000 to 8500 feet, and the series taken near Summerhaven, elevation about 7500 feet. A few specimens of the white-throated wood rat (*Neotoma albigula albigula*) from Black Mountain and from the Tucson Mountains are darker in color than those found on the desert sands or on the light-colored rocks of the other desert mountains. A few specimens of the cactus mouse from Tumamoc Hill also are dark in color. The inclusion of these specimens in their respective series makes the mean color readings for these two species somewhat lower than would be the case if only specimens from the lighter-colored soils were included. In the other species we find no important difference in the color of the animals from different situations, except for those forms which have already been described as distinct subspecies.

Not all the species known to occur in each of the life belts could be included in the table. For many species we have no specimens available from the region. This is especially true of the larger carnivores and artiodactyls. Further, we have been unable to devise a satisfactory technique for securing tint photometer readings of the larger skins. The colors of striped and spotted forms like the skunks, bassarisk, chipmunk, and rock squirrel also cannot be satisfactorily determined by the tint photometer. We have omitted from the section of the table under "desert plain" those forms which are known in the desert belt only from the cottonwood–willow habitat, because the species found only in this riparian association can hardly be considered typical desert species, and, as shown elsewhere, the color of the soil in this habitat is considerably darker than in the other habitats of the desert plain. We have also omitted the species which are generally restricted to the rock hill habitat, for, as is shown in an earlier section of this report, several of the rock hill mammals tend to vary in color depending upon whether they live on black lava or on lighter-colored rock. Under "desert plain" we do list all the smaller species of which skins are at hand from the sandy and gravelly desert near Tucson.

Species of mammals known to inhabit the montane forest belt of the Santa Catalina Mountains are:

Sorex vagrans monticola, Rocky Mountain shrew
Eptesicus fuscus pallidus, large brown bat
Myotis volans interior, little brown bat
Procyon lotor subspecies, raccoon
Bassariscus astutus arizonensis, bassarisk
Spilogale gracilis gracilis, spotted skunk

Mephitis estor, striped skunk
Conepatus mesoleucus venaticus, hog-nosed skunk
Urocyon cinereoargenteus subspecies, gray fox
Felis concolor subspecies, cougar
Lynx rufus subspecies, bobcat
Citellus grammurus grammurus, rock squirrel
Eutamias dorsalis dorsalis, cliff chipmunk
Sciurus arizonensis catalinæ, Arizona squirrel
Thomomys bottæ catalinæ, pocket gopher
Peromyscus maniculatus rufinus, deer mouse
Peromyscus boylii rowleyi, brush mouse
Neotoma mexicana mexicana, Mexican wood rat
Sylvilagus species, cottontail
Odocoileus couesi, Coues deer

The names in bold-faced type in the above list refer to subspecies characteristically montane in distribution in the Tucson region which up to the present have not been reported from the grassland or desert life belt. It is probable, however, that several of the carnivores so listed will later be found to occur at times on the desert. A number of the montane forms listed in bold-faced type occur also in the encinal belt.

Of the montane species, the shrew, large brown bat, small brown bat, chipmunk, pocket gopher, and deer mouse are quite dark in color in comparison with the small mammals of the desert belt. The chipmunk is striped on the back, but its general color tone is dark. The montane pocket gopher, *catalinæ,* is dark in color and has a paler subspecies, *modicus,* living on the desert at Tucson. The montane deer mouse, *rufinus,* also is dark in color and has a paler subspecies, *sonoriensis,* reported from the grassland near Oracle and from the desert at Continental. The Arizona squirrel and Mexican wood rat are both restricted to the montane and encinal belts and both are moderately dark in color, as compared with the desert small mammals, though neither is as dark as the montane pocket gopher or deer mouse. No specimens are available of the raccoon, gray fox, cougar, lynx, cottontail, or Coues deer from the montane belt of the Santa Catalina Mountains and therefore little can be said of their color. The Coues deer is known to be paler in color than the eastern white-tailed deer (*Odocoileus virginianus*), and several of the carnivores mentioned are probably here represented by pale or moderately pale races. Neither are there available specimens of the bassarisk from the upper Santa Catalina Mountains, but it is presumed to be there of the same subspecies and to have the generally pale color which it has on the desert mountains near Tucson. The rock squirrel is rather dark in color and is spotted; it occurs also in the desert on the rocks of Tumamoc Hill and in the cottonwood–willow habitat along the Santa Cruz River. The three genera of skunks are strongly marked with black and white, and at least the spotted skunk occurs also in rock hill habitat on the desert.

The more strictly montane forms are shown by this discussion to have a tendency toward dark pelage colors. Some of the wide-ranging larger mammals, however, such as the Coues deer, are represented in the Santa Catalina

Mountains by pale or moderately pale races, in comparison with related forms found in the heavier forests of other regions. Our information is insufficient to determine whether or not these larger forms are as pale in color as the mammals typical of the desert plains. The bassarisk, which rarely occurs in the higher mountains, is presumed to be pale in color, as it is in rocky habitats on the desert, where it is numerous.

Dark pelage color is especially evident in the montane deer mouse, which is the most common mammal of the dense forests of the upper part of the montane belt. The series of specimens of the deer mouse from the northern slope of Mount Lemmon average only 6.86 (table 7) in tint photometer readings for reflected red, and there is little variability in color tone in the series. The pocket gopher of this belt has a still darker color than the deer mouse, its mean reading for red being 5.00. Even the two species of bat taken here are dark-colored, each having mean readings for red of 7.50. The brush mouse has the lightest color of the species listed from the montane forest, its mean reading for red being 11.06, but this species was not found to be very numerous in the heaviest montane forest, and it ranges downward to the cottonwood–willow habitat on the desert.

The tendency toward dark pelage color shown by the mammals of the heavy forest on the upper part of the Santa Catalina Mountains is in full agreement with the previous observations of naturalists that many of the animals of heavily forested regions everywhere tend to be dark in color.

The mammals of the desert belt tend to have paler colors than those of the mountains. The complete list of species and subspecies known from the desert in the vicinity of Tucson is as follows:

Macrotus californicus, leaf-nosed bat
Myotis velifer velifer, cave bat
Pipistrellus hesperus merriami, canyon bat
Bassariscus astutus arizonensis, bassarisk
Spilogale species, spotted skunk
Vulpes macrotis subspecies, desert fox
Canis latrans subspecies, coyote
Citellus grammurus grammurus, rock squirrel
Citellus tereticaudus neglectus, round-tailed spermophile
Ammospermophilus harrisii harrisii, antelope squirrel
Thomomys bottæ modicus, pocket gopher
Perognathus flavus flavus, Baird pocket mouse
Perognathus amplus taylori, bahada pocket mouse
Perognathus baileyi baileyi, Bailey pocket mouse
Perognathus penicillatus pricei, sand pocket mouse
Perognathus intermedius subspecies, rock pocket mouse
Dipodomys spectabilis perblandus, banner-tailed kangaroo rat
Dipodomys merriami merriami, Merriam kangaroo rat
Dipodomys ordii ordii, Ord kangaroo rat
Onychomys torridus torridus, scorpion mouse
Reithrodontomys megalotis megalotis, harvest mouse
Reithrodontomys fulvescens fulvescens, harvest mouse
Peromyscus eremicus subspecies, cactus mouse

Peromyscus maniculatus sonoriensis, deer mouse
Peromyscus leucopus arizonæ, white-footed mouse
Peromyscus boylii rowleyi, brush mouse
Sigmodon hispidus cienegæ, cotton rat
Neotoma albigula albigula, white-throated wood rat
Mus musculus musculus, house mouse
Lepus alleni alleni, antelope jack rabbit
Lepus californicus eremicus, black-tailed jack rabbit
Sylvilagus audubonii arizonæ, Arizona cottontail
Pecari angulatus sonoriensis, peccary
Odocoileus hemionus subspecies, mule deer
Odocoileus couesi, Coues deer
Ovis canadensis mexicanus, bighorn sheep

The species in light-faced type are those reported in the vicinity of Tucson only from the cottonwood–willow, rock hill, and aerial associations, while the species reported from any of the other associations of the desert plain are in bold-faced type.

Of the Sonoran species listed, the leaf-nosed bat and canyon bat are restricted to desert or arid regions, and both are pale in color as compared with the bats of the eastern United States. The cave bat, on the contrary, is dark in color. The bassarisk, desert fox, and antelope jack rabbit are pale-colored species characteristic of desert and arid habitats. The black-tailed jack rabbit and Arizona cottontail belong to widely distributed species which here in the desert are represented by pale-colored races. We know little about color variation in the coyote, peccary, mule deer, and bighorn sheep, but none of these are described as dark in color in the Tucson desert. The Coues deer ranges from the desert to the top of the Santa Catalina Mountains, occupying all life belts, but it is apparently rare on the desert plains. As noted above, it is pale in comparison with the white-tailed deer of the eastern United States. The rock squirrel is fairly dark in color, but has a darker relative, *douglassi*, in western Oregon and northwestern California. It is more characteristic of the higher mountain belts, and is here reported on the desert only from the rocks of Tumamoc Hill and from the cottonwood–willow association. The cotton rat is quite dark in color, having a mean tint photometer reading for reflected red of only 8.5. Near Tucson it is reported only from cottonwood–willow association and from a grassy spot on Tumamoc Hill. It is more abundant in the grassland belt farther east. The introduced house mouse is quite dark in color, but is not a normal member of the fauna. It was taken only in the cottonwood–willow association. Species reported in the Sonoran province from the cottonwood–willow association only are the Baird pocket mouse, desert harvest mouse, Sonoran harvest mouse, deer mouse, white-footed mouse, and brush mouse. These are all moderately pale in color, but reach their greatest abundance in more humid areas. The Ord kangaroo rat is reported only from near the Santa Cruz River, and it also is pale in color. The rock pocket mouse is closely restricted to rocky habitats and its color variations are discussed in another section of this report. On most mountains in the Tucson district it is pale in color, but the subspecies

nigrimontis, living on the black lava of Black Mountain and of Tumamoc Hill, is dark in color. The cactus mouse is rather pale in color on most desert mountains near Tucson, but on Black Mountain a dark-colored form, *pullus*, is found. The valley pocket gopher (*Thomomys bottæ modicus*) of the desert plain at Tucson is moderately pale in color. The spotted skunk, which is strongly marked with black and white, is the darkest-colored mammal of the desert plain. Our only desert record of the spotted skunk is from Tumamoc Hill, but it is probable that it and perhaps other kinds of skunks are widely distributed over the desert.

Our survey indicates that the only mammals of the desert plain near Tucson which could be classed as dark or moderately dark in color tone are the cave bat, the skunks, the rock squirrel, the subspecies *nigrimontis* of the rock pocket mouse, the subspecies *pullus* of the cactus mouse, the cotton rat, and the introduced house mouse. Even most of the mammals of the cottonwood–willow association are relatively pale in color.

The form of rock squirrel living on the desert near Tucson, while moderately dark in color, is a moderately pale subspecies of its group. Further, it is not reported from the more open habitats of the desert plain. Neither is the cotton rat found in the more arid habitats of the desert plain. The dark subspecies, *nigrimontis* and *pullus*, of the rock pocket mouse and cactus mouse, respectively, are restricted to black lava mountains. We know nothing about the home of the cave bat in our region. The skunks form an exception to the rule in not being correlated in color with the color of the soil.

All the common rodents of the more open habitats of the desert plains near Tucson are pale or moderately so in color. Such are the round-tailed spermophile, antelope squirrel, bahada pocket mouse, Bailey pocket mouse, sand pocket mouse, banner-tailed kangaroo rat, Merriam kangaroo rat, scorpion mouse, and white-throated wood rat. Tint photometer readings are given in table 7 for all these forms except the banner-tailed kangaroo rat, of which we have no specimens from the desert belt.

The palest mammal of the Tucson desert is the bahada pocket mouse (*Perognathus amplus taylori*), which has a tint photometer reading for reflected red of 25.12. The round-tailed spermophile (*Citellus tereticaudus neglectus*), the Bailey pocket mouse (*Perognathus baileyi baileyi*), and the sand pocket mouse (*Perognathus penicillatus pricei*) also have relatively high tint photometer readings. The species with lowest readings (that is, the darkest-colored) of those listed in the table from the desert plain are the cactus mouse (*Peromyscus eremicus eremicus*) and white-throated wood rat (*Neotoma albigula albigula*), both of which are more frequently found on the rock hill habitat than on the desert plains. The inclusion in our series of some dark specimens from mountains of black lava has undoubtedly lowered somewhat the means for both of these species.

The tendency toward pale colors in the pelage of the mammals of the Tucson desert is in full agreement with the conclusions of previous students of desert animals. In every desert region and in many groups of animals this tendency toward pale coloration has been demonstrated.

A general correlation between dark pelage color and forest habitat and between pale pelage color and desert habitat in the Tucson region is clearly demonstrated. This tendency toward a correlation between pelage color and life belt is clearly shown by table 7. The mammals from the montane forest have low tint photometer readings, indicating dark color, while those species living on the desert plain generally have high readings, indicating pale colors. The mammals of the encinal and grassland belts tend to be intermediate in color tone. However, most of the species of these intermediate belts occur also in the montane forest or on the desert plain.

A similar correlation between mammalian pelage color and life belt has been noted in other regions by field naturalists. On the northern slope of the Uinta Mountains in Utah it has been shown by Leraas (unpublished manuscript) that the deer mouse (*Peromyscus maniculatus*) has a fairly dark pelage color in the pine belt, while in the sagebrush belt it is paler and brighter in color.

The contrast between the pale colors of the desert mammals in the Tucson region and the dark colors of the mammals in the forests of the Santa Catalina Mountains is particularly striking because of the short distance between the two life belts. From the summit of Mount Lemmon to Tucson the distance in a direct line is less than 20 miles.

The most important differences in environmental conditions among the several life belts in southern Arizona are in physiography, soil, climate, and vegetation. These features are more or less interrelated. The physiography influences climate and soil, and through these the vegetation. The character of the soil influences the type of vegetation and in part determines the topography. The climate determines the type of vegetation and through precipitation and wind and water erosion it influences topography. The vegetation has an important effect on the character of the soil; it influences the physiography; and in its immediate vicinity it partly controls the climate. The distribution of the animals is controlled by the several environmental factors, and in their turn the animals through their activities affect the soil and the vegetation, and to a lesser extent the physiography.

The montane forest belt has quite a different climate from the desert. Among other differences may be noted its heavier rainfall, greater atmospheric humidity, lower air temperatures, heavier frosts, and shorter growing season. A correlation between atmospheric humidity and the heaviness of pigmentation of birds and mammals has been pointed out by many authors (see Allen, 1906, 385). Most authors, however, use the term atmospheric humidity to cover all the climatic factors concerned with precipitation and evaporation. No conclusive evidence has been produced which demonstrates any direct effect of atmospheric humidity on animal pigments. Nor is there any known manner by which atmospheric humidity could itself exercise a selective effect on the color variations within a species.

High atmospheric humidity is nearly always associated with relatively heavy rainfall, low evaporation rate, and a resulting heavy growth of vegetation. The vegetation, as it dies and decays, produces humus, which, added

to the soil, results in dark soil color. In soils of fine texture, such as silts and sands and clays, the darkness of soil color depends to a large extent on the amount of contained humus (see Hilgard, 1906, 120). High atmospheric humidity is therefore usually correlated with heavy vegetation and dark soil color. It seems probable that the dark colors of birds and mammals in humid regions are related to the heavy vegetation and the dark soil colors rather than directly to the atmospheric humidity or to other climatic factors.

The surface soils of the desert plains are distinctly paler than the soils of the montane forests. In table 8 are given the tint photometer readings of the surface soils in typical stations where mammals were trapped in the Tucson region. These readings of the surface soil colors are directly comparable with the readings of the pelage colors of the mammals given in table 7. The rock hill stations, which are given elsewhere in this report, are omitted from the table.

The soils of the desert plains, with the exception of the cottonwood–willow association, have much higher tint photometer readings than the soils from the montane belt, indicating their paler color, while the encinal and grassland belts have soils which are intermediate in tone of color. A large part of this difference in tone of soil color is undoubtedly due to differences in the amount of humus in the soils of the several life belts. The surface soil in the Douglas fir forest is almost entirely composed of decaying vegetation, and its color is quite dark. On the contrary, the soils of the desert plains apparently contain little humus, although we did not test them for this constituent. The soils from the intermediate life belts are probably intermediate in the proportion of contained humus. In the cottonwood–willow association the soil is shown by the table to average quite dark, and this is evidently due to the presence of much humus in this riparian habitat.

The soil samples of which tint photometer readings were taken were in an air-dry condition. If they had been moistened before taking the readings, those containing humus would probably have had still lower readings than those given in the table, while those without humus would probably have been less affected. Because the soils in the upper life belts are usually at least slightly damp, their color in nature would probably be even darker, in contrast with the pale colors of the desert soils, than the table indicates.

A general correlation between the dorsal pelage colors of the mammals and the surface soils of their habitats is well shown by a comparison of tables 7 and 8. In the montane belt the tint photometer readings of dorsal pelage color and of soil color closely agree. Even the montane bats are dark in color. These animals are perhaps correlated in color with the dark colors of the trunks and limbs of the forest trees against which some of them cling when at rest. Though they probably have no direct correlation with the soil color, their pelage color is similar to that of the ground-inhabiting rodents. The small mammals most restricted to the surface of the ground, such as the deer mouse (*Peromyscus maniculatus*) and pocket gopher (*Thomomys bottæ*), are darkest in color tone. These species have a darker dorsal color

TABLE 8—*Colors of certain surface soils in southeastern Arizona: north slope of Santa Catalina Mountains and Tucson desert. Means and extremes of 10 or more tint photometer readings of each soil sample.*

(Per cent)

Habitat	Red	Yellow	Green	Peacock blue	Blue-violet
Montane forest:					
Douglas fir, Mount Lemmon	10.50 (7–15)	8.67 (6–12)	6.83 (4–8)	5.50 (3–7)	3.92 (2–5)
Encinal:					
Oaks, lower automobile control	15.00 (11–18)	14.08 (11–18)	11.50 (8–14)	9.75 (7–14)	8.33 (7–10)
Oaks, Peppersauce Canyon	12.50 (9–19)	10.92 (6–15)	8.58 (5–14)	7.25 (5–10)	6.42 (3–11)
Grassland:					
Mesquite–grass, 6 miles SE. of Oracle	18.42 (15–21)	15.58 (14–17)	13.08 (10–16)	10.33 (9–11)	9.17 (8–11)
Mesquite–grass, 15 miles SE. of Oracle	17.92 (16–20)	15.25 (12–18)	11.67 (10–13)	9.00 (7–11)	7.67 (6–9)
Palo verde–mesquite–grass, 5 miles N. of Oracle	22.17 (17–27)	19.75 (14–25)	16.92 (12–21)	13.58 (9–20)	11.75 (8–15)
Desert plain:					
Cottonwood–willow, Fort Lowell	16.50 (15–22)	13.92 (11–19)	11.42 (10–16)	10.00 (9–13)	8.92 (8–12)
Mesquite forest, Robles Ranch	33.77 (28–35)	28.08 (24–30)	22.33 (18–25)	18.58 (14–20)	16.92 (11–18)
Palo verde–brittlebush, 8 miles N. of Tucson	34.50 (20–70)	26.67 (14–60)	20.58 (12–50)	16.08 (10–35)	14.17 (8–42)
Upper bahada, Pima Canyon	34.75 (23–66)	29.25 (19–63)	24.00 (15–54)	19.83 (11–50)	17.50 (10–42)

than the dry soil sample from their habitats, but if the soil had been moist when the color was analyzed, its shade would probably have deepened to equal that of these rodents.

The mammals from the encinal and grassland belts are intermediate in shade of color between the mammals of the montane and of the desert belts. In this they agree with the intermediate color tone of the surface soils of these intermediate belts.

None of the mammals of the desert plain near Tucson have dorsal colors as pale as those of the soils of their habitats. The soils of the desert plain listed in the table all average over 33 in tint photometer readings for reflected red. The palest-colored mammal on this plain is the bahada pocket mouse (*Perognathus amplus taylori*), which has an average dorsal reading for reflected red of 25.1. The next higher readings for red in dorsal pelage are found in the round-tailed spermophile (*Citellus tereticaudus neglectus*), with a reading of 19.0, and in the wash pocket mouse (*Perognathus penicillatus pricei*), which has a mean reading of 17.0. However, most desert rodents are paler on the sides than on the dorsal area, and some have white under parts. When viewed from the side most species would appear paler than the readings indicate.

RELATIONSHIP BETWEEN THE HUES OF SOIL COLOR AND PELAGE COLOR

Every soil sample which we have examined has a predominating color tone of buff. The tint photometer readings of each soil sample are highest for reflected red, and each successive color through the spectrum, yellow, green, peacock blue, and blue-violet, has a successively lower reading (table 8). If the color readings for all the color screens were equal, it would indicate a shade or tint of gray. A high reading for any color indicates a predominance of that tone. In all our samples of soils and rocks (figs. 7 and 8) the readings for red are highest and those for yellow next, showing a predominance of a reddish buff color tone.

Some mineral salts are known to have colors of green, blue, or violet. We do not have any samples of soils containing appreciable amounts of such minerals, and so far as we know no soils of such unusual colors cover any extensive areas. As a background for mammals they are probably negligible.

The important differences in color between the several soil samples are those in depth of color. Between some soil samples the difference in shade is very great. Contrast, for example, the tint photometer reading of 74.0 for reflected red of the gypsum soil of the White Sands (table 1) with the reading of 10.3 for the black lava of the Tularosa Malpais (table 2). Yet for both of these soils the readings for red are higher than those for the other color screens, showing that the soil of the White Sands is a light tint of reddish buff, while the lava is a dark shade of a somewhat similar hue.

The differences in hue which are shown by our soil samples are variations between strongly reddish buffs and yellowish buffs which still have a strong

tone of red (see figure 7). For no sample is the tint photometer reading for yellow as high as that for red. It is unfortunate that the tint photometer does not have a color screen for orange, for there probably are somewhat important variations in the proportions of reflected orange as well as of reflected red and yellow. The yellow color screen tends somewhat toward a greenish yellow.

Soil colors from other regions have not so far as we know been analyzed with the tint photometer, but it is probable that the reddish buff hue predominates in surface soils everywhere. In our samples are soils resulting from the weathering of very different types of rocks, and those accumulated by various geologic agencies; also soils containing varying amounts of humus. Soils elsewhere, except in very special conditions, would not be expected to vary greatly in predominant color.

The pelages of North American mammals resemble the soil colors in having prevailing tones of buff. The various species and races range in hue from reddish buff to yellowish buff. This applies both to the species described in this paper (tables 1–7) and to the deer mice previously reported upon by Murie (1933, 10) and by Dice (1932b, 20–21; 1933b, 16, 19; and 1935b, 13). In every series of specimens which we have examined, the tint photometer readings for reflected red are highest, those for yellow are next, and those for green, peacock blue, and blue-violet follow in descending order. In figure 8 the means for several species are plotted to show this relationship graphically. There are considerable differences between species and races in the magnitude of the several means, and this indicates differences in tint and shade of color. The lines representing the several species, however, have rather similar slopes, indicating a general similarity in hue. There are slight differences in the slopes of the lines representing the several species and races, and these differences indicate variations from reddish buff to yellowish buff, but in no specimen which we have examined are the readings highest for any color other than red.

Even the solid black and solid white markings of the skunk are tinged with buff. In figure 8 are given the readings of black and of white areas on the back of a specimen of *Mephitis estor* taken near Summerhaven. It will be noted that the black pelage of the skunk is quite dark, as shown by low tint photometer readings, but that the reading for red is highest of all the five color screens and the readings for peacock blue and for blue-violet are the lowest. On the white stripe of this skunk also the buff tone is very obvious, as is shown by the somewhat higher readings for red and yellow than for the other color screens.

The relative uniformity of hue in mammalian pelages seems to be correlated with the relative uniformity in hue of the surface soils. Most small mammals live in close contact with the soil, and this correlation may indicate a tendency toward concealing coloration, though some other correlating factor may be involved.

The colors of mammals are determined mostly by the color of the hair, for

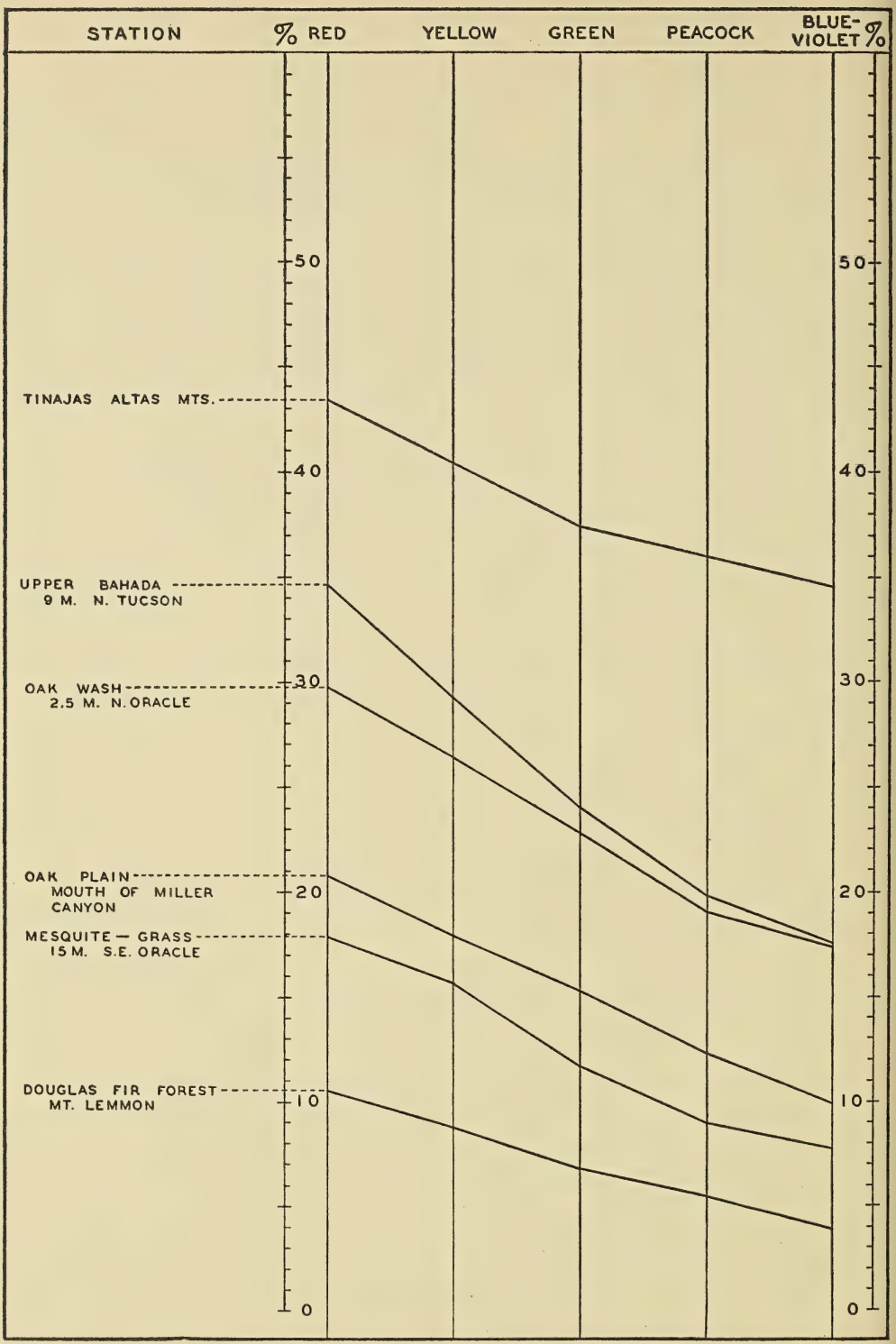

FIG. 7—Graph of colors of certain surface soils from southwestern North America. Mean tint photometer readings of soil samples, in percentages.

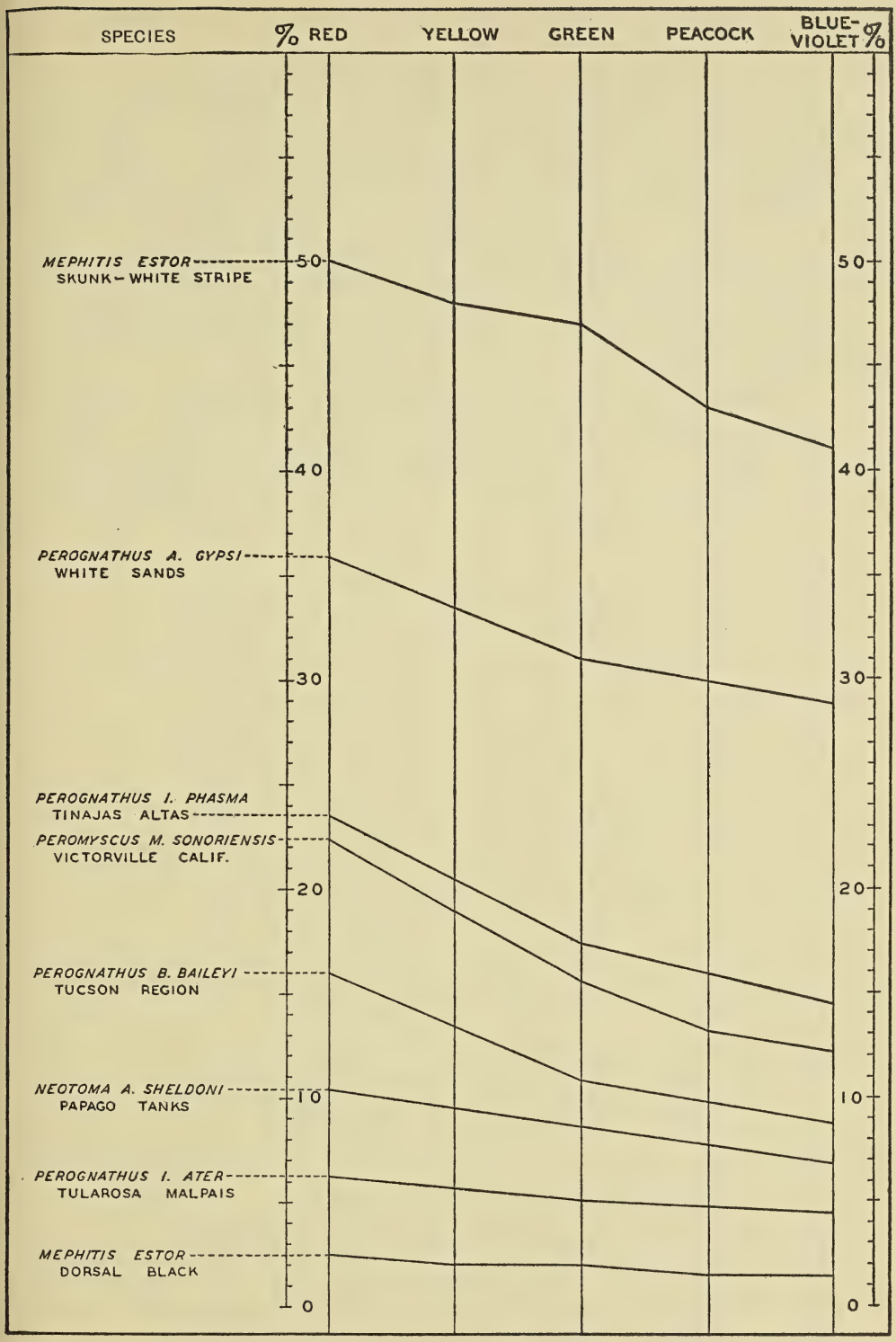

FIG. 8—Graph of colors of dorsal pelage of certain mammals. Mean tint photometer readings of museum specimens, in percentages.

in only a few mammals is any appreciable amount of bare skin exposed. After the hair is formed its pigments are not subject to further change except by slow fading. Some change in the appearance of the animal may be produced by the wearing off of the tips of the hairs, if these are of different color from the rest of the hair, but this also is a slow process. Any other change in the color of the mammal must result from the molt of the old hair and the growth of a new coat. The mammals are therefore unable to change their colors quickly to match the color of the environment in which they find themselves. In this they are unlike fishes, amphibians, and reptiles, many of which are able to change their colors rapidly through changes in the chromatophores in the skin.

The variation in pelage color from dark to light exhibited by the various races of the species of mammals in the Southwest has been shown by Benson (1933, 46–49) to be produced by variations in the depth of pigmentation and in the distribution of pigment bands in the hairs. Dark-colored races have as a rule darker sides and darker under parts as well as darker backs than do light-colored races.

The pigments in the hairs of mammals seem to consist entirely of the melanins (Beddard, 1902, 10). In the feathers of birds there is much more variety in basic pigments. Birds, however, are in general much more arboreal than mammals and therefore sometimes have other backgrounds, such as green leaves, which differ considerably in color from the soil.

The correlation between the colors produced by the melanins and the usual soil colors is perhaps an adaptive relationship. The great majority of mammals live on or under the ground, and their pelage color will be most nearly concealing if it matches the general color tone of the soil in their habitat. Those ancestral mammals, if there were any, with pigments which produced colors different from the usual soil colors may be presumed to have been eliminated, leaving only the forms which use the melanins as pigments.

CORRELATION BETWEEN PELAGE COLOR AND SOIL COLOR

In an earlier section of this report it has been shown that there is a tendency for the pelage color of mammals of the rock hill association on the various desert mountains to be correlated in shade with the shade of color of the rocks. In each rock-inhabiting species there seems to be a tendency for dark-colored races to occur on dark-colored rocks and for pale-colored races to occur on pale-colored rocks. The most complete series of color races is presented by the rock pocket mouse (*Perognathus intermedius*), cactus mouse (*Peromyscus eremicus*), white-throated wood rat (*Neotoma albigula*), and cactus wood rat (*Neotoma lepida*). These are the species of desert mammals which by their habits are most closely restricted to the rock hill habitat. The parallel series of pale, intermediate, and dark-colored races of these mammals living, respectively, on pale, intermediate, and dark-colored rocks on the isolated desert mountains cannot possibly be the result of coincidence.

Neither can the dark-colored and pale-colored races living on these desert

mountains be the result of differences in climate or vegetation between their several habitats, for differently colored races of the same species of mammal frequently occur on mountains separated only by a few miles of desert plain. There is no evidence that these adjacent mountains differ in any important respect either in climate or in vegetation. The only important difference we can discover is in the color of the rocks.

In another section of this report it has been shown that there is a tendency for the color shades of the mammals to be correlated with the life belt. In the montane belt of the mountains the pelage colors of the mammals are mostly quite dark, while on the sandy desert plain the colors of the mammals are mostly pale. Intermediate shades of color commonly characterize the mammals of the intermediate life belts. The species of mammals which occupy the montane belts of the mountains are usually different from the species which occur on the desert plain, so that in this comparison, for the most part, different species are involved. However, all the mammals of each life belt, so far as we can determine, have the same general color trend, the only certain exception being the skunks.

It was further shown that the tendency toward dark colors in the mammals of the montane life belt is correlated with generally dark soil colors in that belt. Conversely, the pale colors of the mammals of the desert plain are correlated with the pale soil colors of the desert plain habitats.

In the most arid part of the Sonoran desert, in southwestern Arizona and northwestern Sonora, occur pale races of the canyon bat, antelope squirrel (*Ammospermophilus harrisii*), valley pocket gopher, bahada pocket mouse (*Perognathus amplus*), Bailey pocket mouse, and Merriam kangaroo rat. We have no soil samples from this region, and we therefore do not know whether or not the exceptionally pale color of many mammalian species in this area is correlated with especially pale soil colors, though we suspect this to be so.

A tendency toward exceptionally dark pelage color in mammals inhabiting dark-colored lava beds in other regions has been reported by previous authors, as was mentioned earlier in this report. Likewise a number of pale-colored subspecies have been described from areas of pale-colored soils even in very humid regions.

The general tendency in mammals everywhere toward pale pelage colors in arid habitats and toward dark pelage colors in regions of heavy humidity and rank vegetation will probably prove on analysis to be actually a tendency toward correlation between pelage color and soil color. Heavy vegetation usually results in an accumulation of humus which gives the soil a dark color. On the other hand, in arid regions with resulting scanty vegetation there is usually little accumulation of humus and the soils tend to be pale in color. Therefore, the soils in habitats which have rank vegetation tend to be dark-colored, while in arid habitats the soils tend to be pale-colored. Our evidence indicates that mammalian pelage color is in part dependent upon soil color. The shade of color of the soil is dependent upon the amount of contained humus, which is dependent upon the amount of vegetation, which in turn

depends in part on climate. The shade of mammalian pelage color, is, therefore, evidently only indirectly correlated with climate.

A correlation between the general hue, as well as the shade, of pelage color and soil color is shown by our studies. We suspect that a close correlation between hue of pelage color and hue of soil color often occurs in habitats where soil of a particular hue covers a wide area, but we have insufficient data to demonstrate this relationship in any instance.

The bats follow the general trend of mammalian color shade and in humid regions are usually dark and in arid regions usually pale in color. Some of the desert bats probably make their homes under or in crevices in the rocks of the desert mountains, and thus there may sometimes be a direct correlation between their shade of color and the color of the rocks. However, in forested regions many of the bats probably roost on trees and thus seldom have direct contact with the soil. We therefore are not certain that the pelage colors of the bats are so directly correlated with the colors of the soils as are those of the ground mammals.

The three genera of skunks, *Spilogale*, *Mephitis*, and *Conepatus*, present the only important exception among the ground mammals of southern Arizona to the tendency toward correlation between pelage color and soil color. Some of the mustelids of other regions which are marked with striking color pattern are probably also exceptions to the rule. The striking markings of the skunks have been assumed by many naturalists to represent advertising coloration (see Roosevelt, 1911, 204–206), though Thayer (1909, 147–151) argues that all species of skunks are concealed by their color patterns from their prey.

A general statement of the rule governing mammalian pelage colors is: The dorsal pelage colors of terrestrial mammals tend to match the color of the soil of their respective habitats. Further studies in many regions will be needed fully to establish the rule, and doubtless other exceptions besides the skunks will be discovered.

SIGNIFICANCE OF LOCAL RACES

Probably the most significant feature of mammalian biology in the arid regions of southwestern North America is the occurrence of many local races. In this region of environmental diversity many species of mammals are represented by two or more varieties. The greatest amount of racial differentiation is shown by several of the rock-inhabiting species, whose habitats on the desert mountains are often interrupted by many miles of desert plain. We follow the common practice of mammalogists in using subspecific names for these races. Similar local races are known to occur in many other regions, though it is seldom that the distinctions between races are so well marked as on the desert.

The occurrence of local races is a common phenomenon in mammals, and mammalogists are well aware that a series of specimens from one locality is never exactly like the series from another locality. In the deer mouse

(*Peromyscus maniculatus rufinus*) the amount of variation from place to place within the range of the subspecies has been shown by one of us (Dice, 1933b, 7–18) to be considerable.

LOCAL AREAS OF COLOR DIFFERENTIATION

In the arid Southwest, where the diversity of environmental conditions is very great, it might be expected that many local races would be developed. In the previous sections of this report this has been shown to be true. On nearly every isolated group of mountains in the area studied by us some species of mammals show peculiar characteristics, and on some of the mountains and on some of the lava beds several species have been modified in parallel directions. It is unnecessary to discuss the modifications in the characters of the mammals which occur at every one of our collecting localities, but it seems desirable to consider briefly the more important places of mammalian differentiation in this region.

Santa Catalina Mountains. The tree squirrel of the Santa Catalina Mountains has been described by Doutt as *Sciurus arizonensis catalinæ.* The color of the back is intermediate between the brown back of *arizonensis*, from northern Arizona, and the more grayish back of *huachuca*, from the Huachuca Mountains. The pocket gopher of the upper part of the Santa Catalina Mountains is very dark in pelage color and has been described by Goldman as *Thomomys bottæ catalinæ.* As is described earlier in this report, the deer mouse (*Peromyscus maniculatus rufinus*) from the heavy coniferous forests on the northern slope of Mount Lemmon is very dark in color, much darker than specimens from 1000 feet lower near Summerhaven. Doutt (1934, 264) has pointed out differences between these mice and those from San Francisco Mountain, the type locality of *rufinus.* The subspecies *bullata* of the Mexican wood rat (*Neotoma mexicana*) is restricted to the forest belts of the Santa Catalina Mountains. It differs slightly in color and cranial characters from another race (*mexicana*) of the same species living in the upper parts of the Chíricahua Mountains.

Santa Rita Mountains. A dark-colored race of the encinal pocket gopher (*Thomomys umbrinus burti* Huey) has been described from the upper Santa Rita Mountains. A moderately dark and richly colored subspecies (*quercinus* Burt and Campbell) of the same pocket gopher occurs in the oak belt of the Pajarito Mountains, which are a part of the Santa Rita district. The paler subspecies *proximus* Burt and Campbell occurs at the lower edge of the oak belt on the western side of the Santa Rita Mountains.

Huachuca Mountains. The tree squirrel *Sciurus arizonensis huachuca* of the Huachuca Mountains has a grayer, less brown back than does the related subspecies *arizonensis* in northern Arizona. The encinal pocket gopher (*Thomomys umbrinus intermedius*) from the upper Huachuca Mountains has been described by Mearns (1897, 719) as a dark-colored form. A reddish buff race of another species, the valley pocket gopher (*Thomomys bottæ extenuatus*), occurs on the reddish buff soils near the mouth of Miller Canyon.

From the Huachuca Mountains a considerable number of peculiar races and species of birds, reptiles, insects, and mollusks have been described, and this isolated mountain area is evidently a place of considerable organic differentiation.

Chíricahua Mountains. The tree squirrel of the Chíricahua Mountains, *Sciurus chiricahuæ* (Goldman, 1933a, 71–72), has tawny forearms and thighs and a grizzled back and is more brightly colored than the related species *apache* of the Sierra Madre Occidental of Mexico. The valley pocket gopher of the upper Chíricahua Mountains is a "small, dark" subspecies, *Thomomys bottæ collinus* (Goldman, 1931a, 421–422). A distinct species of pocket gopher, *Thomomys umbrinus*, is represented in the upper parts of these mountains by the subspecies *chiricahuæ* (Nelson and Goldman, 1934, 117), of which the upper parts are "near cinnamon" in color and usually lack the black median dorsal area of *intermedius* from the Huachuca Mountains. At an elevation of 8000 feet on Rock Creek were taken the only known specimens of *Reithrodontomys megalotis arizonensis*, a dark-colored race of harvest mouse.

White Sands. The most abundant small mammal on the gypsum White Sands of the Tularosa Basin of southern New Mexico is a nearly white form of the Apache pocket mouse (*Perognathus apache gypsi* Dice), which is not known to occur elsewhere. The wood rat of the White Sands (*Neotoma micropus leucophæa*) is said by Goldman (1933, 472–473) to be slightly paler in color than the related subspecies *canescens* of the adjacent desert. On the other hand, the pocket gopher (*Geomys arenarius brevirostris* Hall) of the White Sands is somewhat darker than the related subspecies *arenarius* at El Paso. However, Benson (1933, 25–26) found that these pocket gophers occur mostly in areas of damp sand; the gypsum soil when damp is yellow in color, and the gophers match the color of the damp sand quite closely.

Tularosa Malpais. On the extensive black lava of the Malpais in the Tularosa Basin of south central New Mexico no less than five species of mammals show tendencies toward dark coloration. The rock squirrel (*Citellus grammurus tularosæ* Benson), the rock pocket mouse (*Perognathus intermedius ater* Dice), the long-nosed mouse (*Peromyscus nasutus griseus* Benson), and the white-throated wood rat (*Neotoma albigula melas* Dice) have been described as dark-colored races. The cactus mouse (*Peromyscus eremicus*) is variable in color on this lava bed, and while some individuals are very dark, others are of the usual pale *eremicus* color (Benson, 1933, 38–42).

Kenzin lava. Extensive lava beds occur near the railroad siding of Kenzin, in Dona Ana County, New Mexico. A sample of the lava collected by Seth B. Benson from this bed (see table 2) is not so dark in color as the Tularosa Malpais lava, and is somewhat similar in color to the lava of Black Mountain, near Tucson. The rock pocket mouse (*Perognathus intermedius rupestris* Benson) of the Kenzin lava is a dark-colored race. The cactus mouse (*Peromyscus eremicus*) and the white-throated wood rat (*Neotoma albigula*) are both very variable in color on this lava bed, and some individuals are quite dark. They are perhaps tending "in the direction of the development of a dark color which would match that of the lava field" (Benson, 1933, 17).

Black Mountain and Tumamoc Hill. On Black Mountain, which is an isolated butte of black lava lying about 10 miles south of Tucson, occur a dark-colored race of the rock pocket mouse (*Perognathus intermedius nigrimontis* Blossom) and a dark-colored race of the cactus mouse (*Peromyscus eremicus pullus* Blossom). The same race of rock pocket mouse occurs also on Tumamoc Hill, another butte of somewhat less dark-colored lava lying just west of the city of Tucson. On Tumamoc Hill these mice average somewhat lighter in color than on Black Mountain, but they are much darker than the same species on the light-colored rocks of the southern Santa Catalina Mountains at Pima Canyon and of the western side of the Tortollita Mountains (see table 2).

Tumamoc Hill lies near the southeastern end of the Tucson Mountains, being separated only by a narrow pass from these mountains, which are composed of rocks generally lighter in color than the rocks of Tumamoc Hill. The rock-inhabiting mammals of Tumamoc Hill are therefore not so completely restricted to the dark-colored rocks of the hill as they would be if it were more isolated. This perhaps explains part of the considerable variability in pelage color of the rock pocket mouse and of the cactus mouse on Tumamoc Hill.

Some individuals of the white-throated wood rat (*Neotoma albigula albigula*) taken on Black Mountain are very dark in color, being rich blackish buff, but other individuals taken at the same place are as pale as those found on mountains of light-colored rocks in the Tucson region. One wood rat taken on the Tucson Mountains is also decidedly dark in color.

Pinacate lava. The black Pinacate lava, which covers an extensive area in northwestern Sonora and crosses into the state of Arizona, is an important center of differentiation for mammals. The following dark-colored races have been described from this area: rock pocket mouse (*Perognathus intermedius pinacate* Blossom), cactus mouse (*Peromyscus eremicus papagensis* Goldman), white-throated wood rat (*Neotoma albigula sheldoni* Goldman), and cactus wood rat (*Neotoma lepida bensoni* Blossom).

The races of the rock pocket mouse and of the two species of wood rat are strikingly dark in color. The cactus mouse is more variable in color and does not average so dark. All the species of mammals which in this region are closely restricted to the rock habitat show modification toward darker color, except possibly the bighorn sheep, the color variations of which are not well known. Hunters believe that the bighorns of the Pinacate region actually are especially dark.

At some places at the border of the Pinacate lava, black sand and dust have been blown out over the adjacent desert sand, forming a thin surface cover of black. On this blackish soil at Papago Tanks and at Elegante Crater some individuals of the wash pocket mouse (*Perognathus penicillatus pricei*) are much darker in color than is typical of the subspecies. Two of the specimens from Papago Tanks are dark in color, while five are typical gray buff. The only specimen of this species taken at Elegante Crater is dark in color. The

dark coloration of these aberrant wash pocket mice is much less intense than that of the rock pocket mice, which are more restricted to the rock habitat.

On the northern extension of the Pinacate lava flow in Arizona, Blossom found the rock pocket mouse numerous. Of twenty-eight taken in one night on this dark-colored lava, all except one are dark in pelage color and identical with *Perognathus intermedius pinacate* from Papago Tanks. The one aberrant specimen is a pale gray buff, similar to other subspecies of this mouse living on the adjacent mountains of southern Arizona, which are made up of rocks of pale hues (Blossom, 1933, 5). Three cactus mice were taken on the Pinacate lava in Arizona. These were shipped to the University of Michigan and one pair of these animals produced young which are assigned to *papagensis*. None of the original animals were preserved as specimens. The one specimen of white-throated wood rat taken on the Pinacate lava in Arizona does not resemble the dark-colored *sheldoni* from Papago Tanks and other parts of the Pinacate lava in Sonora, but on the contrary is so pale in color that it is referred to *mearnsi*, the subspecies which occurs on the Tinajas Altas Mountains and also near the Agua Dulce Mountains. This pale-colored individual possibly may be a migrant from the nearby mountains, or it may indicate interbreeding with the adjacent pale races.

Tinajas Altas Mountains. A number of species of rock-inhabiting mammals have developed pale-colored races on the pale-colored rocks of the Tinajas Altas Mountains, which lie mostly in southwestern Arizona near the Mexican boundary. A pale-colored race of the rock pocket mouse (*Perognathus intermedius phasma* Goldman) is, so far as our present information goes, restricted to the Tinajas Altas Mountains and the adjacent Raven Butte, which is mostly composed of black lava. A pale-colored subspecies (*Peromyscus crinitus disparilis* Goldman) of the canyon mouse occurs on the pale-colored rocks of the Tinajas Altas, Cabeza Prieta, and Tule Mountains; also on the dark-colored rocks of the Wellton Hills and of the Gila Mountains at Telegraph Pass, and on the black lava of Crow Butte. A pale-colored race of the white-throated wood rat (*Neotoma albigula mearnsi* Goldman), which lives on the Tinajas Altas Mountains and on Raven Butte, is reported (Goldman, 1915, 135–136) also from Tule Wells and from "Granite Mountains (near Tule Wells)," both of which localities are probably in light-colored rock. The cactus wood rat is represented on the Tinajas Altas Mountains by a pale-colored subspecies (*Neotoma lepida flava* Benson).

As has been described in an earlier section of this report, the rock habitat of Raven Butte is not completely isolated from the immediately adjacent Tinajas Altas Mountains, and rock-inhabiting mammals are able to pass freely back and forth between the black lava of the butte and the pale granites and gneisses of the mountains. The area of the butte is so much less than that of the mountains that it is not surprising that the color of the mammals on the butte is similar to the color of those taken on the lighter-colored rocks of the mountains. Actually some of the palest individuals of

the rock pocket mouse were taken on the black lava of Raven Butte, but this is undoubtedly only a coincidence.

The rock pocket mouse was found by Blossom to be much less numerous on Raven Butte than on the Tinajas Altas Mountains, and he secured only eleven on the butte in three nights of intensive trapping. The smaller numbers of this pale-colored race on the black rocks of the butte may possibly indicate a higher mortality in this situation, where the animals would not be protectively colored.

Tucson desert plain. Several mammals of the desert plains have developed peculiar subspecies in the vicinity of Tucson. None of these subspecies are restricted to the desert, but all extend their range upward to include the grassland belt. The valley pocket gopher (*Thomomys bottæ modicus*) occurs on the desert plain near Tucson and also in the grassland belt at La Osa in the Altar Valley (Goldman, 1931a, 418). Another subspecies of the valley pocket gopher has been described by Goldman (1931a, 422–423) from an altitude of 3000 feet on the Coyote Mountains, which lie near the north end of the Baboquivari Mountains. Its geographical range is unknown. The bahada pocket mouse (*Perognathus amplus taylori*) is common on the desert near Tucson, but is also reported (Goldman, 1932a, 488) from the grassland belt on the Santa Rita Range Reserve, 35 miles south of Tucson, and Dice took it at the lower edge of the grassland belt 5 miles north of Oracle. It is not known from east of the Santa Rita Mountains. The banner-tailed kangaroo rat (*Dipodomys spectabilis perblandus*) is reported from the desert near Tucson, but it is more numerous in the grassland belt on the Santa Rita Range Reserve (Vorhies and Taylor, 1922, 8). It is not known from west of the Baboquivari Mountains.

Of these peculiar subspecies, the pocket gopher is paler in color than a related subspecies on the upper parts of the Santa Catalina Mountains, but darker than forms from the more arid desert farther west in the Yuma biotic district. The bahada pocket mouse is darker than the related subspecies *rotundus* from the Yuma district. The banner-tailed kangaroo rat is paler and smaller than a related form, *spectabilis*, from the grassland belt farther east in southeastern Arizona. A number of desert species do not range farther east than the Tucson district, and a number of grassland and desert subspecies do not extend west beyond the general limits of the district. The Tucson district is rather slightly marked as an area of differentiation of races, though it is an important distributional and ecological unit.

Desert plain of southwestern Arizona and northwestern Sonora. Several of the species of mammals living in sandy habitats on the very arid desert plains of southwestern Arizona and northwestern Sonora (Yuma biotic district) have developed geographic races which are paler in color than the related races found in the desert around Tucson. In table 9 are given only those sand-inhabiting forms known to be represented in the two districts by different subspecies. The subspecies of canyon bat occurring in the Tucson

district is rather uncertain, for though several were shot at Sabino Canyon, near Tucson, they were not preserved.

It will be noted that every one of the subspecies listed from the Yuma district is paler in color than the related race or races of the same species in the Tucson district. These paler colors are correlated with the greater aridity of the Yuma district.

The rainfall records given by Mallery (1936, 119) and by Smith (1930, 388) show that the precipitation is very scanty in southwestern Arizona and along the Gulf of California in Sonora. The annual precipitation at Tucson averages around 11 to 12 inches, but stations at Tinajas Altas, on the adjacent Lechuguilla Desert, at Tule Tank, and on the Pinacate lava in Arizona average less than 4 inches rainfall per year. Two stations near Puerto Libertad, Sonora, average between 4 and 5 inches of annual precipitation. This scanty rainfall together with the high temperatures of the region necessarily results in extreme desert conditions.

TABLE 9—*Comparison of mammals of Tucson and Yuma biotic districts. Species of the rock hill and riparian habitats and those not differing in subspecies in the two districts are omitted.*

Species	Subspecies	
	Tucson district	Yuma district
Pipistrellus hesperus, canyon bat	*merriami* (?)	*hesperus*
Ammospermophilus harrisii, antelope squirrel	*harrisii*	*saxicola*
Thomomys bottæ, valley pocket gopher	*modicus* and *pusillus*	*depauperatus*, *phasma*, and *vanrossemi*
Perognathus amplus, bahada pocket mouse	*taylori*	*rotundus*
Perognathus baileyi, Bailey pocket mouse	*baileyi*	*domensis*
Dipodomys merriami, Merriam kangaroo rat	*merriami*	*simiolus*
Onychomys torridus, scorpion mouse	*torridus*	*perpallidus*

LOCAL RACES MAY INDICATE ECOLOGIC TRENDS

Many of the local races with which we are dealing are distinguished by the color of the pelage, and it has been shown in an earlier section of this report that in the mammals of this region the color of the pelage tends to be correlated with the soil color of the habitat. The parallel development in many diverse species, genera, and families of mammals of similarly colored races on areas characterized by a particular soil color lends strong support to the hypothesis that the color of the mammals is in some way dependent upon the color of the soil. On the humus-filled, dark-colored soils of the mountain forests the small mammals tend to be dark in color, while on the pale-colored desert soils the mammals tend to be pale in color. Those species which range widely over soils of many color shades tend to be intermediate in shade of color. On the black lava of the Tularosa Malpais four species of rock-inhabiting rodents have developed local subspecies, all of which are characterized by dark pelage color, and another species shows a tendency in this direction. On the black Pinacate lava of northwestern

Sonora all the rock-inhabiting rodents, four in number, have developed dark-colored subspecies.

The development of subspecies and local races is then at least in part an ecologic tendency. Dark-colored races tend to develop on dark-colored soils, and light-colored races tend to develop on light-colored soils. The large number of local color varieties which are found in our region clearly demonstrates this ecologic trend.

The proportions of the parts of the body are known to vary in many mammals in correlation with the habits and habitats of the animals. Grassland-inhabiting deer mice, such as *Peromyscus maniculatus bairdii*, often have shorter tails, smaller ears, and shorter hind feet than related subspecies, such as *P. m. artemisiæ*, which inhabit forests. We did not make a study of the degree of correlation between body proportions and habitat in the mammals of our region, but it is probable that such a correlation exists in many species and subspecies. Therefore, many of the races and species distinguished by body proportions may possibly also represent ecologic tendencies.

POSSIBLE IMPORTANCE OF NATURAL SELECTION IN THE PRODUCTION OF LOCAL RACES

The tendency for the pelage colors of mammals to resemble the color of the soils of their habitats, which is shown by so many of our species, is very possibly an adaptive modification of the mammals for concealment. Such a relationship might have arisen by the action of natural selection operating through predators, as has been pointed out by Benson (1933, 51–62). This, however, is denied by McAtee (1934, 1–4). Our data do not furnish any evidence that natural selection is effective in producing these races, but no other hypothesis seems logically adequate to explain the repeated parallel development, on a soil of a particular color, of similarly colored races in widely diverse species, genera, and families. Natural selection by some agency other than predators is a possibility, but no plausible hypothesis for the occurrence of such a type of selection has yet been presented.

No internal factor alone could possibly be responsible for the production in a single species always of pale-colored races on light-colored soils, and always of dark-colored races on dark-colored soils. In the rock pocket mouse (*Perognathus intermedius*) four different dark-colored subspecies have been described from our region, each from a different bed of dark-colored lava, and two pale-colored races of the same species occur on separated areas of pale-colored rocks. No internal directive force can account for these divergent tendencies. The indication is that the local races of these desert mammals have been produced in response to environmental factors, probably acting through selection of some sort.

Differences in climate or vegetation are wholly inadequate to explain the differences in the colors of these local races. Frequently pale-colored and dark-colored races of the same species occur on desert mountains which are

separated only by 10 to 50 miles of desert plain, and which have, so far as we can observe, almost identical climates and identical vegetation.

That the environment does not directly produce racial characters through an effect on each generation of animals is certain, for the characters of at least some of these local races are inherited. Breeding stocks of several races of the cactus mouse (*Peromyscus eremicus*) brought from the Sonoran desert to the Laboratory of Vertebrate Genetics of the University of Michigan have produced young which in each case possess the racial characters of their parents. Sumner (1925, 364) previously has shown that the characters of at least some desert races of mice are inherited.

Natural selection, if it is an effective cause in the production of these local races, would find in most mammalian populations ample material on which to operate. Many local populations of our desert rodents show wide variability in pelage color, as has been shown by Benson (1933, pl. 2) for the rock pocket mouse from the Kenzin lava bed. At least part of the individual variability in body proportions and pelage color in a population of the deer mouse (*Peromyscus maniculatus*) has been shown (Dice, 1933b, 18–26) to be inherited. In most populations there is probably sufficient variability of hereditary characters already present to produce several local races if sufficiently rigorous selection in the proper directions could be maintained for a number of generations.

It seems highly probable, therefore, that natural selection has been an important factor in the production of the local races of the desert regions. The precise method by which natural selection operates has, however, not been determined with certainty, nor is anything known about the rigor of selection exercised by the various presumed selective agencies.

RÔLE OF ISOLATION IN THE PRODUCTION OF LOCAL RACES

Isolation is undoubtedly of importance in the production of local races of mammals, as has been stated by Benson (1933, 55–56). On Raven Butte, which is not isolated from the adjacent Tinajas Altas Mountains, no dark-colored races have developed, while on Black Mountain, which is isolated from the nearest mountains by several miles of desert plain, several of the rodents show trends toward darker color. In the absence of isolation, a distinct race would not be likely to develop on a small area, for the characters of the incipient race would tend to be swamped by continued interbreeding with the surrounding populations.

On large areas, however, geographic races occur in spite of the absence of barriers to free interbreeding. There is no definite physical or climatic barrier to interbreeding between the desert plains mammals of the Tucson and Yuma districts in southern Arizona, yet a number of species are represented by different subspecies in the two districts (table 9). Undoubtedly many or all of the subspecies of the Yuma district are continually interbreeding at the borders of their ranges with their relatives in the Tucson district. The failure of interbreeding to swamp the characters distinguishing the related

subspecies indicates that the process which has produced the subspecific differences is still in operation.

Several types of soil color are frequently found on the same desert mountain or on small parts of the desert plains. In such situations the pelage color of the mammals obviously cannot be correlated with all the soil colors. If the different soil colors cover about equal areas, our impression is that the mammals have a more or less intermediate color tone. If one type of soil color is dominant in amount of area covered, the mammals will tend to be correlated with the dominant soil color. An example is given by the connected Tinajas Altas Mountains and Raven Butte, where the mammals tend to be correlated in pelage color with the rock color of the Tinajas Altas Mountains.

The most distinct color races occur on isolated areas which have soil colors all or nearly all of one general tone. Examples are Black Mountain near Tucson, and the Pinacate lava. The area of the isolated situation also seems to be important. The color races of the Pinacate lava are more distinct and more uniform than those of Black Mountain, though this may result in part from a greater degree of isolation.

In the differentiation of local races the age of the area is undoubtedly of importance, for on the newest lava beds, for instance, there might not yet have been time for the production of a divergent race. This may be the explanation for the failure of Sumner (1921, 81–86) to discover any tendency toward the development of a dark local race of the canyon mouse (*Peromyscus crinitus*) on a lava bed in the Mohave Desert.

The size of the isolated area may also affect the rapidity with which new local races are differentiated, but we have nothing to indicate whether differentiation occurs more rapidly on large or on small isolated areas.

"PREADAPTATION"

The principle of preadaptation has been suggested (Goldschmidt, 1933, 541) to explain the origin of adaptive characters in local races. This then would perhaps explain the correlation between pelage color and soil color in desert mammals.

It is, however, not entirely clear to us just what Goldschmidt means by preadaptation. If he means that new mutations arise in any part of the range of the species and are transferred, if they survive, throughout the species by breeding, thereby possibly reaching situations where the effect produced is adaptive, we agree that this is a plausible hypothesis. We would, however, register an objection to the term "preadaptation," which to us carries a taint of teleology. Furthermore, no special term would seem to be necessary for this phenomenon, for all mutations, except those producing important defects, may be of adaptive value somewhere, at some time, and in proper combination with other hereditary and environmental factors.

The original use of the term preadaptation by Cuénot (1911, 415–420) implies that races sometimes are produced with combinations of characters fitting them to other environments in addition to those in which they live.

This concept is logical, but has a limited application. Davenport (1903, 18–21), in formulating his theory of segregation in the fittest environment, states that in at least some cases "an external condition existed first and a structure or coloration was acquired by the race that fitted or adjusted it to that situation."

It is very probable, as was pointed out by Cuénot and Davenport, that adaptations arising in one habitat may fit an organism for life in other somewhat similar types of habitat, but the origin of the first adaptation still needs explanation.

Adaptation results from the combination and relationship of many characters, genetic, morphogenic, and environmental, and preadaptation therefore also implies combination and relationship of characters. Preadaptations of this sort might conceivably arise in an intermediate region between two types of environmental conditions, and might allow the spread of a species into an area which previously it had been unable to inhabit. This is the kind of situation which Goldschmidt apparently has in mind in his use of the term. But these are certainly not the conditions under which many of our desert races of mammals have arisen. The most strikingly marked desert races occur on isolated mountains or lava beds, and their combinations of characters have almost certainly developed in the exact areas which the races now occupy. A pair of black rock pocket mice wandering on the desert plain looking for the black lava bed to which they are "preadapted" would be in a most unfortunate predicament.

Even in a region of intermediate environmental conditions at the borders of the range of a species, the modifications which might arise fitting the species to extend its range into previously inhospitable territory would, in most cases, be actually of an adaptive rather than preadaptive character. We have no doubt that adaptive modifications at the borders of the range of a species may often be of considerable evolutionary importance and may well lead to the production of new geographic races. Some of the subspecies living on the desert plain of southern Arizona may have originated in this manner. This method of evolution is, however, probably not of importance in situations where the habitats are widely separated from one another, as they are on the desert mountains. Here the gradual evolution of color varieties accompanied by migration into the proper ecologic situations would not be possible.

ARE GEOGRAPHIC RACES INCIPIENT SPECIES?

Many biologists consider that geographic races may be incipient species. However, Goldschmidt (1933, 542) concludes as a result of extensive studies that this is not true. Let us examine the ranges and characters of some of the local races of mammals in the southwestern deserts to determine what indication they give of developing into species.

The various races of one species of mammal seem always to be fertile when crossed, and the hybrids also are fertile. This has been demonstrated by laboratory breeding for many subspecies of several species of *Peromyscus*

(Dice, 1933, 298–305). Different species, on the contrary, except closely related ones, are not interfertile. Many species of desert mammals fail to breed when kept in captivity, but the cactus mouse (*Peromyscus eremicus*) breeds well in the laboratory and a number of its desert races are fertile together when crossed. It seems probable that all our local races of one species are fertile together, but it is unlikely that any of the desert species of mammals which we have discussed would produce fertile hybrids.

Many of the local races which occur on the southwestern deserts have apparently developed in response to the characters of the environment. The tendency toward a correlation between pelage color and soil color is abundantly demonstrated by our studies.

The place of origin of some at least of the local races we have studied must be the precise locality where the race now lives. A local race which is characterized by its pelage color, as most of our local races are, and which is confined to an area having soil of a similar color, must have been produced on that particular area of soil or on some adjacent area of similar soil color. These color races seem to occupy, in general, the whole area of suitable habitat and suitable soil color. A possible exception is the occurrence on the northern edge of the Pinacate lava in Arizona of a pale-colored individual of the white-throated wood rat, rather than the dark-colored race *sheldoni*.

Many of the local color races of the desert mountains cannot extend their ranges beyond their present limits on account of the barrier of the surrounding sea of desert sand. Should some individuals of the race be able to cross this barrier to some other mountain having soil of a different color, they would find themselves unadapted in pelage color. If they should be able to colonize the new area, it would be expected that their descendants would tend to assume a pelage color which would harmonize with the soil color of the new habitat. In other words, the characters of the parent race would tend to disappear and perhaps a new race would be produced in the new situation. Only if the emigrants should reach a mountain with soil color similar to that of the original home would the range of the race be permanently extended.

The local races of the desert plains are not in general limited in distribution by physical barriers, except in so far as the Colorado River may prevent the westward distribution of some forms. The desert mountains are not continuous in any direction and the habitats of the desert plains extend completely around these mountains. Nevertheless, a number of species are represented by different subspecies in the Yuma and Tucson biotic districts (table 9). It must be assumed that these desert plains races also have originated in environments similar to those which they now occupy. The maintenance of the distinctive characters of two races of the same species, in spite of the interbreeding which undoubtedly occurs where the two races meet, must be assumed to be due to a continued natural selection of some sort, which must be of different trend in the range of each subspecies.

Should the environmental factors which have produced a local race change, that local race would have to change its characters to fit the new conditions,

or it might become extinct. Changes in environment affecting races could occur by the weathering down of the mountains which are the home of a particular race, by the raising of the mountains to higher elevations, by the extrusion of lava within the range of the form, by a change of climate which would alter the type of vegetation in the habitat, or perhaps by other kinds of changes. While changes in the environment might produce changes in the characters of the mammalian populations, perhaps leading to the production of new local races, there is no evidence that such changes would produce new species.

While a new species might differentiate from an isolated race through the production of an infertility with its relatives, there would seem no more likelihood of a new species originating from an isolated race than from any other isolated division of a species. As pointed out by Stern (1936, 139–141), interspecific sterility is probably a by-product of evolution. Isolation followed by the production of hereditary variations preventing fertile crossing with related races would seem to be the essential feature in specific differentiation. Such differentiation could theoretically occur in island forms under similar ecologic conditions even in races which superficially might completely resemble one another, but which ultimately would be infertile when mated. Actually, the accumulation of random mutations of either positive or neutral selective value in isolated races would, in addition to the changes in fertility, probably result in racial differences recognizable by the taxonomist.

Most geographic races, therefore, probably do not represent incipient species, but are only responses to a local type of environment. To this extent we agree with Goldschmidt. However, it is possible for geographic races or groups of races, if they remain isolated for a long enough time, to differentiate sufficiently to be considered distinct species, according to the present usage of the term by mammalogists. For instance, the deer mouse (*Peromyscus maniculatus*) and the old-field mouse (*Peromyscus polionotus*) produce fertile offspring in the laboratory, but in nature the ranges of these two species nowhere overlap.

Isolation, which is apparently an important factor in the development of local races, is theoretically an important factor also in the formation of species. The isolation which results in the formation of a local race might, if continued over a long period, result in the production of a distinct species. However, local races can be produced, as we have shown, without isolation, and with continued interbreeding in such a situation specific infertility would seem unlikely to develop.

Our conclusion is that the production of species may theoretically result from a continuation of the processes of isolation, mutation, and selection which are assumed to be effective in the production of local races, but that most races are probably not to be regarded as incipient species.

SUMMARY

Many local races of mammals, distinguished for the most part by differences in pelage color, occur in the arid regions of southwestern North America.

In general, dark-colored races occur on dark-colored soils and pale-colored races on pale-colored soils. The evidence seems conclusive that in the Southwest the pelage color of the mammals tends to be correlated with the color of the soils of their habitats. In the Southwest only the skunks, which have a color pattern of black and white, are known to be exceptions to this general ecologic trend.

Isolation is an important factor in the production of local races, and the occurrence of many isolated mountains on the southwestern deserts has been a contributing factor in the production of the numerous local subspecies. However, differentiation into subspecies sometimes occurs in places where physical barriers to distribution are absent.

These local races are not necessarily incipient species, though species may theoretically be produced through a continuation of the same processes of isolation, mutation, and selection which are assumed to be operative in the production of local races.

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A—Oak association, encinal belt, Santa Catalina biotic district; at the lower control station on the automobile road between Oracle and Summerhaven, northern slope of the Santa Catalina Mountains, Pima County, Arizona; elevation about 5600 feet; June 4, 1932. The open spaces between the oak trees are characteristic.

B—Douglas fir association, montane belt, Santa Catalina biotic district; on the northern side of Mount Lemmon, Pima County, Arizona; elevation about 8500 feet; June 23, 1932. Note the thick cover of vegetation on the humus-filled soil.

A—Sycamore association, encinal belt, Santa Catalina biotic district; in Peppersauce Canyon, 8 miles southeast of Oracle, Pinal County, Arizona; elevation about 4600 feet; July 7, 1932.

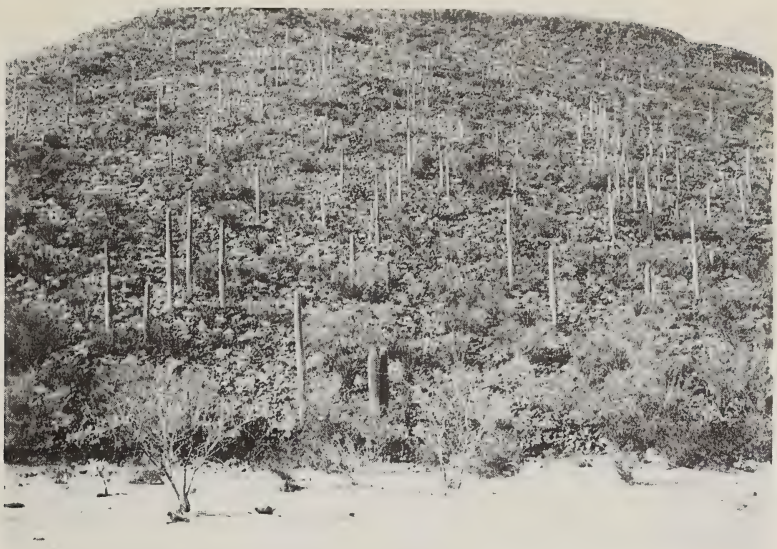
B—Brush mouse (*Peromyscus boylii rowleyi*) in oak tree at the mouth of Miller Canyon, Huachuca Mountains, in Cochise County, Arizona; July 30, 1932. These mice are semi-arboreal in habit and when released from a trap they often run up the nearest tree.

A—Mesquite–grass association, grassland belt, Santa Catalina biotic district; 6 miles southeast of Oracle, Pinal County, Arizona; elevation about 4400 feet; July 10, 1932. On the higher slopes to the right appears the encinal belt of the Santa Catalina Mountains.

B—Sacaton association, grassland belt, Huachuca biotic district; beside the San Pedro River, near Hereford, Cochise County, Arizona; elevation about 4100 feet; August 1, 1932. Cottonwood–willow association appears in the distance.

A—Upper bahada association, Tucson biotic district; 9 miles north of Tucson, Pima County, Arizona; elevation about 2900 feet; April 15, 1930. The ocotillo (to the right), palo verde (center), giant cactus or sahuaro (distance), and brittlebush (foreground) are characteristic plants. Many large to small rocks occur on the surface of the ground. This situation is about 1 mile from the base of the Santa Catalina Mountains.

B—Rock hill association, Tucson biotic district; near the Desert Laboratory on Tumamoc Hill, at Tucson, Pima County, Arizona; elevation about 2700 feet; April 19, 1930. Characteristic mammals of the rock hill association in the Tucson district are the rock pocket mouse (*Perognathus intermedius*), cactus mouse (*Peromyscus eremicus*), and white-throated wood rat (*Neotoma albigula*). The desert mountains are frequently isolated from each other by miles of desert plain, and on these isolated mountains the rock hill mammals have developed numerous peculiar races, most of which are correlated in pelage color with the color of the rocks of their habitats.



A—Black Mountain, 10 miles south of Tucson, Pima County, Arizona; from the south; Tucson biotic district; March 1931. On this butte of black lava the rock pocket mouse (*Perognathus intermedius nigrimontis*) and the cactus mouse (*Peromyscus eremicus pullus*) have developed dark-colored races. Some but not all of the white-throated wood rats (*Neotoma albigula*) living here are also very dark in color.

B—Raven Butte, Yuma County, Arizona; from the south; showing the contact between the black lava and the pale-colored rocks of the Tinajas Altas Mountains; Yuma biotic district; October 8, 1932. The rock pocket mouse (*Perognathus intermedius phasma*), white-throated wood rat (*Neotoma albigula mearnsi*), and cactus wood rat (*Neotoma lepida flava*) have been described as pale-colored subspecies, mostly restricted to the Tinajas Altas Mountains and to the adjacent Raven Butte.

A—Crow Butte, Yuma County, Arizona; from the west; Yuma biotic district; October 15, 1932. The Cabeza Prieta Mountains are in the distance.

B—The desert plain between Crow Butte (right) and an outlying spur of the Cabeza Prieta Mountains (distance); looking southward; October 15, 1932. The nearest approach of the butte to the mountains is estimated to be about ¼ mile. The black lava composing the butte contrasts strongly in color with the pale rocks of the Cabeza Prieta Mountains. The tree at the camp is a palo verde, one of the few trees in the whole region. A typical desert bahada slopes upward to the base of the mountains. In the left distance the lower part of the bahada merges with the general level of the desert plain.

A—Creosote-bush covered plain beside Cerro del Colorado, an outlying crater of the Pinacate group, northwestern Sonora; from the southwest; April 23, 1933. The plain in the foreground is covered with a thin layer of black cinders.

B—Pinacate Mountains from near Elegante Crater; looking a little south of west; April 24, 1933. The edge of the Pinacate lava shows in the middle distance. The soil in the foreground is covered with a thin layer of black dust, and the one specimen of wash pocket mouse (*Perognathus penicillatus pricei*) taken here is abnormally dark in color.

A—Pinacate lava plain viewed from Papago Tanks, Pinacate Mountains, northwestern Sonora; looking a little south of east; April 26, 1933. On this black lava bed the species of rock-inhabiting rodents are all represented by dark-colored races: *Perognathus intermedius pinacate, Peromyscus eremicus papagensis, Neotoma albigula sheldoni,* and *Neotoma lepida bensoni.*

B—One of the water holes at Papago Tanks; April 26, 1932. A higher water line shows on the rocks. The rocks around the water hole are of granite, while those in the distance are of black lava. It is about 60 miles from this water hole to Sonoyta, where is found the nearest dependable, drinkable water.

INDEX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